



34<sup>th</sup>
Annual Conference & Exhibition on NON DESTRUCTIVE

EVALUATION & ENABLING TECHNOLOGIES





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# T H E CONTENTS



PROGRAM AT GLANCE

**MESSAGES** 

**MEMORIAL TALKS** 

**PLENARY TALKS** 

**INVITED TALKS-SCIENTIFIC** 

**INVITED TALKS-INDUSTRY** 

**CONTRIBUTED PAPERS** 

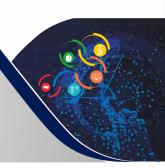
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**ADVERTISMENTS** 



DAY 1: THURSDAY, 12th DEC 2024							
9:15 - 10:45 hrs	NDE CONFERENCE INAUGURATION						
10:45 - 11:00 hrs	EXHIBITION INAUGURATION						
11:00 - 11:30 hrs	TEA BREAK						
11:30 - 13:00 hrs	MEMORIAL TALKS						
	11:30-12:15	Mr. Ramesh Bhai Parikh Memorial Talk					
	12:15-13:00	3:00 Dr. Baldev Raj Memorial talk					
13:00 - 14:30 hrs	LUNCH						
14:30 - 16:00 hrs	PLENARY SESSION: I						
16:00 - 17:00 hrs	OPEN SESSION (Poster Session-I, Visit toExhibition & Tea Break)						
	Workshop on "Scientific Writing by Springer Nature" - Hall C - RAMAN						
17:00 - 18:30 hrs	TECHNICAL SESSION: 1						
	Hall A - BHABHA	Hall B - KALAM	Hall C - RAMAN	Hall D - SARABHAI	Hall E - BOSE		
	Structural Health Monitoring	NDE for Aerospace: Metallic Components - I	NDE for Energy Sector-I	Advances In Radiography Imaging	Nill		
18:30 Onwards	CULTURAL PROGRAMME & NETWORKING DINNER						





		OAY 2: FRIDAY, 1	3th DEC 2024				
09:00 - 10:00 hrs	PLENARY SESSION: II						
10:00 - 10:30 hrs	Panel Discussion on Indian NDT Certification Schemes						
10:30 - 11:00 hrs	TEA BREAK						
11:00 - 12:30 hrs	TECHNICAL SESSION: 2 (INDUSTRY)						
	Hall A - BHABHA	Hall B - KALAM	Hall C - RAMAN	Hall D - SARABHAI	Hall E - BOSE		
	Nuclear	EV & Batteries	Aerospace	Oil &Gas	Joint Session of Professional Societies		
12:30 - 14:00 hrs	LUNCH						
14:00 - 15:30 hrs	TECHNICAL SESSION: 3						
	Hall A - BHABHA	Hall B - KALAM	Hall C - RAMAN	Hall D - SARABHAI	Hall E - BOSE		
	Special Sessions for Students - NDT for Career Opportunities & Enabler For Entrepreneurship	NDE for Aerospace: Metallic Components-II	Advances in UT: Phased Array-I	Applications of NDE in Energy Sector-II	Computed Tomography		
15:30 - 16:30 hrs	OPEN SESSION (Poster Session-II, Visit toExhibition & Tea Break)						
16:30 - 18:00 hrs	TECHNICAL SESSION: 4						
	Hall A - BHABHA	Hall B - KALAM	Hall C - RAMAN	Hall D - SARABHAI	Hall E - BOSE		
	Electromagentic NDE	NDE for Aerospace: Non-Metallic Components	Advances in UT: Phased Array-II	Applications of NDE in Energy Sector-III	Sensors For NDE		
18:00 - 19:00 hrs	OPEN SESSION (Poster Session-III, Visit to Exhibition), ISNT AGM (Only for ISNT Members)						
19:00 Onwards	GALA DINNER						



DAY 3: SATURDAY, 14th DEC 2024							
09:00 - 10:30 hrs	PLENARY SESSION: III						
10:30 - 11:00 hrs	TEA BREAK						
11:00 - 12:45 hrs	TECHNICAL SESSION: 5						
	Hall A - BHABHA	Hall B - KALAM	Hall C - RAMAN	Hall D - SARABHAI	Hall E - BOSE		
	NDE for Concrete Industry-I	Advances In Ultrasonics: Instrumentation & Acquisition	NDE 4.0 - Way Forward	Infrared Thermography	NDE for Structural Integrity-I		
12:45 - 14:00 hrs	LUNCH						
14:00 - 15:30 hrs	TECHNICAL SESSION: 6						
	Hall A - BHABHA	Hall B - KALAM	Hall C - RAMAN	Hall D - SARABHAI	Hall E - BOSE		
	NDE for Concrete Industry-II	Advances in UT: Impact of AI, Guided Wave, Non-Linear Ultrasonics	Applications of NDE in the Processing Industry	Training for Empowerment - Impact of AI and the Way forward	NDE for Structural Integrity-II		
15:30 - 16:00 hrs	TEA BREAK						
16:00 - 16:30 hrs	VALEDICTORY FUNCTION						

भारतीय अन्तरिक्ष अनुसंधान संगठन

भारत सरकार अन्तरिक्ष भवन

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#### MESSAGE

I am delighted to note that the Indian Society of Non-Destructive Testing is organizing the 34th Annual Conference & Exhibition on Non-Destructive Evaluation & Enabling Technologies (NDE-2024) during 12th to 14th of December 2024 at Chennai, Tamil Nadu.

The multi-disciplinary nature and the multi-domain applicability of Non-Destructive Testing & Evaluation make this continuously evolving field, as an area of interest to



global researchers, who are looking at expanding its applications to different materials and associated products. The field has now been further enriched with advanced computational modelling & imaging including the adoption of the latest technologies such as Artificial Intelligence (AI) & Machine Learning (ML). As the Indian Space Programme expands its vision to include space stations and human spaceflight missions to the moon in the next decade, the judicious application of these techniques becomes essential to ensure quality, reliability & sustainability with economic efficiencies. I am glad that the conference is focusing on a broad spectrum of existing & emerging techniques included under the NDE umbrella.

I am sure that the conference will continue to serve the NDE community as a networking platform for industry, academia and research institutions to discuss the ongoing research and advances in the field.

I wish a grand success for the Conference.

Date: November 27, 2024

(सोमनाथ एस / Somanath S)

### डॉ. समिर वी. कामत Dr. Samir V. Kamat



भारत सरकार Government of India



MESSAGE

सचिव, रक्षा अनुसंधान तथा विकास विभाग एवं अध्यक्ष, जीआरजीओ Secretary, Department of Defence R&D & Chairman, DRDO

- It gives me an immense pleasure to be a part of NDE-2024 Conference and Exhibition, the annual flagship event of ISNT. This year, the event is being held from 12-14 Dec 2024 in Chennai.
- 2. ISNT is a non-profit organisation with the basic objective of scientific development and promotion of NDE science. NDE has become an indispensable part of Quality Assurance and Reliability programs of all the industries. It plays a very important role in integrity assessment. It helps in identifying discontinuities which are detrimental to the performance of the product and process, ensuring safety and seamless operations in all areas.
- 3. The development of NDE science has many aspects including research and development, equipment manufacturing, process development, implementation of procedures, service in the field, development of code standards and specifications, education, training, certification etc. One can find all these parameters under one roof in this conference and exhibition which will be of immense benefit to the practicing NDE professionals from different organisations.
- 4. The yearly conference is an opportunity for all, technicians, managers, service personnel, buyers, sellers, students and anyone connected to the field of NDE. The conference is a dynamic array of events which includes the Inauguration Talk, Exhibition Stalls, Plenary Sessions, Invited Talks, Quiz Competitions, Cultural Programs, Special Sessions with industrial interactions along with Preconference Tutorials on carefully selected subjects, making it a place where NDE evolves.
- I convey my best wishes to all the contributors along with the entire team of NDE 2024 and wish the conference and exhibition a grand success.

Stamat

(Dr. Samir V. Kamat)





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#### MESSAGE



It gives me immense pleasure to extend my greetings to all the participants of the NDE 2024 Conference & Exhibition, organized by the Indian Society for Non-Destructive Testing (ISNT) in Chennai from December 12 to 14, 2024. This prestigious event continues to serve as a vital platform for professionals, researchers, and industry leaders to discuss advancements and innovations in Non-Destructive Testing (NDT), a field of paramount importance for ensuring safety, quality, and reliability in industrial and infrastructural applications.

Non-Destructive Testing has witnessed remarkable growth over the years, with ionizing radiation techniques playing a pivotal role. Applications of various NDT techniques are indispensable in sectors like power generation, aerospace, construction, oil and gas, and manufacturing, where precision and integrity are non-negotiable. The use of ionizing radiation in NDT for industrial radiography has significantly enhanced the accuracy and reliability of defect detection, contributing to the overall safety and efficiency of industrial operations.

While ionizing radiation offers immense benefits in NDT applications, it is crucial to emphasize radiation safety as a cornerstone of all operations involving radioactive sources or X-ray equipment. Atomic Energy Regulatory Board (AERB) ensures the safe use of ionizing radiation in all spheres, including NDT. Regulatory frameworks, rigorous safety standards, and periodic audits are in place to minimize exposure risks to workers, the public, and the environment. I urge all stakeholders to prioritize safety, adhere strictly to the prescribed guidelines, and foster a culture of awareness and responsibility in radiation usage.

NDE 2024 presents an excellent opportunity to discuss advancements in NDT technologies and strengthen our collective determination to enhance safety protocols. I commend ISNT for its unwavering commitment to promoting excellence in NDT and fostering collaboration among diverse stakeholders.

I wish the conference grand success and hope it will lead to meaningful discussions, innovative solutions, and strengthened safety practices for a brighter and safer future in NDT.

ई-मेल /E-mail : chairman@aerb.gov.in / dkshukla@aerb.gov.in, वेवसाइट./ WEBSITE : www.aerb.gov.in



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NIYAMAK BHAVAN, ANUSHAKTINAGAR, MUMBAI - 400 094

(Dinesh Kumar Shukla)





विवेक भसीन Vivek Bhasin निदेशक, भाभा परमाणु अनुसंधान केंद्र Director, Bhabha Atomic Research Centre सदस्य, परमाणु ऊर्जा आयोग Member, Atomic Energy Commission



#### MESSAGE

I am very pleased to note that Indian Society for Non-Destructive Testing (ISNT) is organizing Conference and Exhibition on 'Non-Destructive Evaluation & Enabling Technologies' at Chennai from Dec 12-14, 2024. The theme of the event 'Imagine, Innovate, Ignite, Inspire' has been thoughtfully chosen, putting a great deal of emphasis on inquisitiveness and research, which are central to the growth of any technology, and NDE is no exception.

NDE is playing a crucial role in our pursuit of achieving 'zero failures' of components working under various operating conditions. Be it quality control during manufacturing or in-service inspection to assess structural integrity for continued service, NDE plays a very vital role during life-cycle of an engineering component. In India, the growth in NDE Science and Technology is driven by the demands from strategic sectors like nuclear, space and defence. Many advanced NDE techniques, which are now routinely used in various industries have gone through rigorous stages of development and validation in strategic sectors. As these sectors continue to progress, there are new challenges that require development and application of NDE techniques, which are sensitive, reliable, fast and more informative.

The Indian industry is taking rapid strides embracing the fourth industrial revolution. It is the collective responsibility of NDE community associated with research, sensors & instrumentation, data analysis, application, training & certification to ensure that the developments in NDE keeps up the pace with the requirements of industry for smooth and effective transition to NDE 4.0. There cannot be a better platform than NDE 2024, to deliberate on the challenges involved during this transition and work out the solutions, which are not just efficient but also cost-effective for their implementation on a larger scale.

I am very happy to note that an exhibition showcasing state-of-the-art NDE equipment and technologies will be running concurrently with the conference. Professionals involved with research as well as those involved with the application of NDE in various industries will be eager to know about the technologies available at their disposal, which they can use effectively in their respective fields.

I am sure the delegates will have an enriching experience at the upcoming NDE 2024 conference and exhibition. I wish the event a grand success.

03.12.2024

(Vivek Bhasin)



### सी. जी. कऱ्हाडकर प्रतिष्ठित वैज्ञानिक एवं निदेशक



भारत सरकार परमाणु ऊर्जा विभाग इन्दिरा गाँधी परमाणु अनुसंधान केन्द्र कल्पाक्कम 603 102, तमिलनाडु, भारत

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY
INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH
KALPAKKAM 603 102, TAMIL NADU, INDIA

# C.G. KARHADKAR Distinguished Scientist & DIRECTOR



November 26, 2024

#### MESSAGE

I am glad to note that the 34th Annual Conference and Exhibition on "Non Destructive Evaluation and Enabling Technologies" is being organized by the Indian Society for Non-Destructive Testing (NDT), at Chennai, Tamil Nadu during December 12-14, 2024. This conference is organized at a significant juncture when our energy and manufacturing sectors, are gearing up for significant transformation, towards attaining self reliance (Aathma Nirbharata) and aligning with global standards, wherein reliability and quality are the key markers.

With significant advancements in NDT, it is essential to share the breakthroughs and explore/widen the applications to modernize all the sectors. It is hence, appropriate to have this conference, at this juncture to highlight the recent advancements, emerging technologies, challenges and opportunities in this domain. I am happy to note that this conference also brings together entrepreneurs across the globe to showcase their products and services for the benefit of the participants.

I appreciate the efforts of the Indian Society for Non-Destructive Testing for creating this unique platform for deliberations amongst the experts and peers. I am confident that this conference would enhance knowledge sharing, collaboration and innovation towards achieving greater goals.

Wish the conference a great success.

(C.G. Karhadkar) Director



### प्रो. प्रतीक किशोर Prof. Prateek Kishore



विशिष्ट वैज्ञानिक एवं महानिदेशक (आयुध एवं समाघात अभियांत्रिकी) रक्षा अनुसंधान एवं विकास संगठन (डी.आर.डी.ओ)

Distinguished Scientist & Director General
(Armaments & Combat Engineering)
Defence Research & Development Organisation (DRDO)



It gives me immense pleasure to know that NDE-2024 Conference and Exhibition, the annual flagship event of ISNT is being held from 12 to 14 December 2024 in Chennai.

Non-destructive Testing is an integral part of almost all products developed by Armament and Combat Engineering cluster of DRDO and as DG of this technical cluster, the deliberations of the conference are useful for implementation in terms of research, development, equipment manufacturing, process development, implementation of procedures, service in the field, development of code standards and specifications, education, training and certification.

The conference is a good opportunity for engineers, managers, service personnel, buyers, sellers, students and professionals, who are associated with NDE in one form or the other.

I am sure that sharing knowledge and networking will be useful in long run for the "Make in India" initiatives of the country to attain "Atmanirbhar Bharat" Goals.

I appreciate the initiative and wish a grand success for the event.

(Prof. Prateek Kishore)

DS & DG(ACE)





#### Message

It is an immense honor to be part of the 34<sup>th</sup> Annual Conference & Exhibition on Non-Destructive Evaluation and Enabling Technologies (NDE 2024) during 12-14<sup>th</sup> December 2024 at Chennai

This gathering stands as a testament to the relentless pursuit of Excellence and innovation in the field of Non-Destructive Evaluation (NDE). As we come together to celebrate our achievements and share our knowledge, I am reminded of the critical role NDE plays in ensuring the Quality, Reliability and Safety of our Products being deployedin various important Industrial process plants. The manufacturing industry's quest for 100% First Time Right makes NDE an indispensable tool. Moreover, the integration of Industry 4.0 technologies has transformed the NDE landscape, enabling Industry to improve product Quality, reduce maintenance costs, deskilling and increase Customer satisfaction. Companies that adopt NDE 4.0 technologies can differentiate themselves from competitors and establish a leadership position in their respective markets. Today's advancementswill pave the way for bright future tomorrow

I commend the Organizers Indian Society for Non-Destructive Testing for bringing together experts from Academia, Research and Industry to share knowledge and innovations in NDE. I urge the participants to leverage this platform to explore new frontiers in NDE and drive its implementation in industries

Wishing the seminar great success and looking forward to the enriching discussions and outcomes

Best Regards,

#### **ANIL V PARAB**

Member-L&T Board

Whole-Time Director (Heavy Engineering & L&T Valves)

Email: Anil.Parab@larsentoubro.com



Krishnan Balasubramaniam Institute Professor MDS 301 Phone: +91 (44) 2257-4662

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It gives me great pleasure to learn that the NDE2024 MEGA event in the field of Nondestructive Testing is being organized by ISNT along with the ISNT Chennai Chapter this year between 12-14 Dec 2024 in Chennai, INDIA.

NDE2024 is a forum designed to bring together researchers, teachers, trainers, students, product developers, marketing managers and end-users from a wide cross-section covering education, transportation, energy, defense, space, among many other domains, all under a single roof of the CHENNAI TRADE CENTER.

NDE2024 facilitates the emergence of new ideas through brainstorming sessions, free exchange of information, exciting demonstrations and discovery of new possibilities in the field of Nondestructive Evaluation.

The NDE2024 edition of the Annual Conference and Exhibition of ISNT promises to set a new benchmark in the extent of success, with over 1400+ exhibitors, 50+ sponsors and supporters, and 175 presentations and 2 Pre-conference Tutorials on NDT for Civil Infrastructure (Indo-German) and on Data Engineering with Phased Array Ultrasonic Testing (Indo-UK) as well as 4 Industry focus sessions and IGNITE special session for the student community.

Several International Societies including ICNDT, APFNDT, MSNT, NDTSS, ASNT, AWS, AMPP,InSIS, and MSME, among others are partnering with ISNT to make NDE2024 an unforgettable experience.

The ISNT organizing team has worked very diligently over the past 12 months to ensure the success of this event. I thank each one for the support and encouragement. We hope thatNDE2024 will provide every attendee a great experience and I am eagerly looking forward to being a part of this experience.

Prof. Krishnan Balasubramaniam President, ISNT

डॉ. कोमल कपूर Dr. Komal Kapoor

#### उत्कृष्ट वैज्ञानिक एवं मुख्य कार्यपालक Outstanding Scientist & Chief Executive



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### Message

NDE fraternity have a major responsibility in the societal transformation and the technological advancement adapting innovative ways in an extremely fast pace. The entire NDE fraternity leaves foot print on the marvelous achievements happening in the country and around the world. Essentially the demand of the hour is to align ourselves for fulfilling the national mission. In this respect, transition towards advanced NDE techniques from conventional one with the synergistic adoption of automation, robotics, sensors, artificially intelligent systems, will play dominant role.

It is of proud privilege and honor to welcome you all in the upcoming NDE 2024 Conference – A platform to NDE professional, researchers, academia and industry to converge for igniting professional minds and innovate in the field of Non-Destructive Evaluation. The theme of the conference is aptly chosen as "Imagine, Innovate, Ignite, Inspire" keeping in mind the exciting technological development around the world. The conference provides a premier platform to all the NDE professionals for sharing ideas with expert in the field, creates ambience for in-depth interaction and collaborate industry, academia and R&D centers.

The Organizing Committee is committed to offer a blend of dynamic technical program along with state-of-art exhibition of NDE technologies from Industry across the globe. Special emphasis will be on latest trend in the field of conventional and advanced NDE with adoption of artificial intelligence, Machine learning, automation, robotics and advanced sensors. The conference also wishes to experience the presence of NDE in the field of medical science, biology and beyond. Apart from all these, the conference venue being in the city of Chennai which is close to several heritage sites and serine natural beauties, will surely make the joyful stay of the participant.

We are so confident that the 34th National Conference and Exhibition (NDE-2024) will turn out to be the most successful platform for networking and inspiring new technical ideas with the support from all of you. I cordially invite all to participate with full enthusiasm in this NDE festival, to enrich and experience the taste of a truly global event.

With my best wishes and regards,

Place: Hyderabad Date: April 30, 2024









It is animmense pleasure to welcome each one of you to the annual conference and exhibition of the Indian Society for Non-destructive Testing (ISNT), Non-destructive Evaluation - 2024 (NDE-2024) being held at Chennai from December 12-14, 2024 on behalf of the technical committee. Time immemorial has proven that this prestigious annual ISNT flagship event is eagerly looked after by all our Non-destructive Testing and evaluation (NDT & E) fraternity. Moreover, the event has shown continual success in promoting awareness regarding technological advances via a series of keynote talks from eminent experts both from industry and academia.

As it has always been, this conference & exhibition has provided an excellent opportunity to share ideas in the cutting-edge technological developments in the field of NDE. Furthermore, the exhibitors have showcased their leading products and state-of-the-arttechnologies with the participants attending across the globe.

In continuing with the rich tradition set up every year, NDE-2024 hopes to bring together one unifying platform for all NDT & E practitioners, including but not limited to researchers, academicians, technologists, practising engineers and students. As indicated globally, this conference has again shown us in true spirit the growing interest in the field of NDE 4.0 nationally via a wide number of interesting works by various researchers. More interestingly, at this conference, there is a unique opportunity to listen to and debate the sector-specific applications of NDE 4.0, which were carefully included in relevant sessions for the benefit of all participants. We also attempted to equally balance the broad field of NDT by including dedicated sessions to topics such as Phased array ultrasonics, infrared thermography, radiography and many more advanced topics. In addition, through special industry sessions, the delegates will also have a unique opportunity to interact directly with industry experts in areas of nuclear, EV& batteries, aerospace and oil&gas. There is a session by Springer Nature on scientific writing which will be of great benefit to the budding researchers. An exclusive session for students will expose them into the possible entrepreneurship and career opportunities in the area of NDE. All in all, we truly believe that this mega event will be a mirror to reflect the growing importance of advanced NDE science as a field of research and practice. We are also very sure that this platform will act as a catalyst in this endeavour to exchange ample knowledge and opportunities in NDE.

In conclusion, we extend our hearty thanks to all the speakers, authors, exhibitors, event managers and people who are involved directly or indirectly to contribute to the success of NDE-2024. Praise is also due to the program committee members and reviewers who have invested significant valuable time in holding and maintaining the standard of quality of the talks at the conference.

We extend best wishes for the splendid success of the event.



#### Convenor's Message (NDE 2024 Souvenir)

Safety and Integrity of assets and structures have gained utmost importance in the past few decades. Failures and accidents have become unacceptable in all sectors of industries. The slogan that all "failures and accidents are preventable" is no longer just a goal. There is a demand to meet this goal in letter and spirit. India is growing very fast in infrastructure development across all industry sectors. As we grow big, the impact of failures and accidents are also significantly magnified and gets noticed across the globe.

The involvement of NDE in achieving this goal of "Zero failure and accidents" is expanding day by day. Development in NDE technology is keeping pace with the accelerated growth in infrastructure. As the infrastructure design and construction is becoming complex, the testing methods are also becoming more technically advanced and sophisticated. The entry of non-metals into the infrastructure development has risen the bar for NDE technologists. Newer and improvised NDE technologies are being conceived to support the never-ending demands of the industry.

Industry leaders are demanding undiminished operating efficiencies from the assets till they are retired. This is, indeed a very big challenge for the in-service inspection personnel to meet. The demand are as follows. Inspection is expected to be done

- a) On-line
- b) Fast
- c) Available on demand within the country
- d) Real-time, if needed
- e) Optimum cost

NDE technologists are taking this challenge head on. India is becoming a hub for NDE technology development. Not only are the industry giants investing in this technology development, but a cluster of young and energetic start up groups have also joined the band wagon in this niche innovation race.

The computing power and use of drones is also transforming the way conventional NDE's are being applied to the assets.

The theme of NDE 2024 conference Imagine / Innovate / Ignite / Inspire reverberates with the mood of the nation building and the immense potential, that is being unleashed by the infrastructure boom.

NDE 2024 conference and the exhibition is the ideal place to update oneself with the latest development in NDE technology and network with the innovators and professionals from across the globe in NDE.

Wish the exhibition and conference a grand success and I sincerely hope that all the attendees will immensely be benefitted from the event and everyoneright from a student to end user of NDE to professionals will have a bagful to take home.

My special thanks to all sponsors, supporters, advertisers, exhibiters, technical paper contributors, invited speakers and the delegates.

My sincere appreciation and complements to the entire team of NDE 2024 including the members of various committees.

Umakanthan Anand Convenor NDE 2024





# MEMORIAL TALKS

34th Annual Conference & Exhibition on NON DESTRUCTIVE EVALUATION & ENABLING TECHNOLOGIES

DEC 12-14, 2024 • CHENNAI



### **Dr Baldev Raj Memorial Talk**



Satish S. Udpa

Department of Electrical and Computer Engineering Michigan State University
East Lansing, MI 48864, USA

Satish S. Udpa serves as an Interim President Emeritus and University Distinguished ProfessorEmeritus at Michigan State University (MSU). Prior to this, he served in many academic and administrative capacities at MSU including Interim President, Executive Vice President for Administration, Dean of the College of Engineering, Chair of the Department of Electrical and Computer Engineering and University Distinguished Professor. He also served as the President of the Michigan State University Foundation. Dr. Udpa was the Whitney Professor of Electrical and Computer Engineering at Iowa State University and a faculty member at Colorado State University before joining Michigan State University in 2001.

Udpa's research interests span the broad area of sensing and measurement. He has focused his energies on developing a variety of sensors for nondestructive evaluation (NDE) applications together with several numerical tools for developing them and analyzing data generated by such sensors. He has published extensively, holds several patents, and was the technical editor of the Electromagnetic Nondestructive Testing Handbook, published by the American Society for Nondestructive Testing. He served as the editor of the IEEE Transactions on Magnetics and the regional editor of the International Journal of Applied Electromagnetics and Mechanics until recently.

He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), American Society for Nondestructive Testing (ASNT), the Indian Society of Nondestructive Testing and the Engineering Society of Detroit. He is also a Fellow of the National Academy of Inventors. He currently serves as a member of Michigan Governor's Council on Future Mobility and Electrification and is a member of the Board of Directors of the American Society for Nondestructive Testing.





# Novel Methods for Improving the Quality of Additively Manufactured Components

Oleksii Karpenko, Lalita Udpa and Satish Udpa Department of Electrical and Computer Engineering Michigan State University East Lansing, MI 48864, USA

THE ABSTRACT

Additive manufacturing techniques find widespread applications in small volume production settings, prototyping or when building components that are difficult to produce using conventional manufacturing methods. The technology involves building the component layer-by-layer, thereby minimizing waste that subtractive manufacturing methods often entail. Although the first generation of additive manufacturing systems were focused largely on building plastic components, metal additive systems have taken root in recent years. Two of the more popular metal additive methods include the Powder Bed Fusion method and the Directed Energy Deposition method. Both methods involve the use of an energy source such as a laser or an electron beam to melt either a thin layer of metal powder at a small spot or a wire and deposit the molten metal on a bed of previously deposited metal. The energy source is selectively turned on and off to build the metal component in incremental layers. The component bed is constantly moving relative to the energy source to build the three-dimensional component.

The melt pool dynamics created by the interaction of the energy and the metal is fairly complex with multiple physical processes at work. The dynamics are controlled by a number of variables including, the power level, bed velocity, beam size, feed rate and ambient conditions. Failure to control these parameters properlycan cause the vapor pressure to exert a force on the molten material resulting in the formation of a cavity. Also, when the recoil momentum produced by the vapor exceeds the pressure produced by the surface tension, conditions are ripe for the formation of what is often referred to as a key hole. The presence of these pores, keyholes and other defects can impair the structural properties of the component being produced.

This talkpresents a new method for improving the process by reducing the probability of flaws being formed during the manufacturing process. The method involves the use of Lorentz forces to churn the melt pool during the process. The force is generated using a combination of an eddy current and a static magnetic field that are oriented in appropriate directions in relation to the melt pool. Simulation results showing the validity of the approach are presented.



### Ramesh Bhai Parikh Memorial Talk



**Sri U. Subba Rao**General Manager of Integral Coach Factory (ICF)

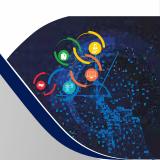
Sri U. Subba Rao, assumed charge as the General Manager of Integral Coach Factory (ICF) on 01.02.2024.

Sri Subba Rao belongs to the 1987 batch of Indian Railway Service of Mechanical Engineering (IRSME). He is a Graduate in Mechanical Engineering and has done Post Graduate Programme in Public Policy & Management with Indian Institute of Management, Bengaluru.

Before assuming charge as G M/ICF, Sri Subba Rao was holding the office of the Additional General Manager, South Western Railway, Hubbali. He has also worked in various capacities in railways including Principal Chief Mechanical Engineer of South Western Railway, Chief Mechanical Engineer (Planning) of South Central Railway, Secunderabad, Divisional Railway Manager (DRM) of Salem Division, Southern Railway, Chief Workshop Manager, Coaching Workshop, Mysuru, in South Western Railway, and Chief Workshop Engineer, at the Rail Wheel Factory, Bangaluru.

He has attended the Senior Managers' Program at Paris and Johannesburg. He was also involved in validation of the EMU Cast Wheels Design at TTCI in the USA





# Evolution of Integral Coach Factory – Vande Bharath Journey

Sri U. Subba Rao General Manager of Integral Coach Factory (ICF)

THE ABSTRACT

The talk will showcase Integral Coach Factory's (ICF) remarkable journey from manufacturing self-generating coaches to advanced, self-propelled, semi-high-speed trains like Vande Bharat.

#### **Key Focus Areas**

- 1. Transformation: From conventional coaches to cutting-edge, self-propelled trains.
- 2. DPRS (Distributed Power Rolling Stock): ICF's innovative approach to meet growing passenger demands.
- 3. Passenger Requirements: Adapting to changing passenger needs and rail sector growth.
- 4. National Rail Plan: Aligning with India's rail development vision.

#### Vande Bharat Highlights Version 1 & 2 Comparison

- 1. Passenger amenities
- 2. Safety features
- 3. Speed potential

#### Variants of Vande Bharat Trains

- 1. Vande Sleeper Version: Enhanced comfort and luxury.
- 2. Namo Bharat (Vande Metro): Efficient, urban transportation solution.

#### **Key Takeaways**

- 1. ICF's commitment to innovation and excellence.
- 2. Strategic evolution to meet changing passenger needs.
- 3. Advanced technologies and safety features.

#### **Presentation Objectives**

- 1. Showcase ICF's growth and achievements.
- 2. Highlight Vande Bharat's features and benefits.
- 3. Emphasize ICF's role in India's rail sector development.

This presentation will inspire and educate audiences about ICF's remarkable journey and contributions to India's rail industry.





# PLENARY TALKS

34<sup>th</sup>
Annual Conference & Exhibition on
NON DESTRUCTIVE
EVALUATION & ENABLING
TECHNOLOGIES

DEC 12-14, 2024 • CHENNAI







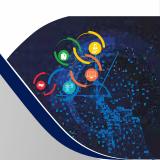
Ms. Anuja Anand
Director, NABL

Mr. AnujaAnand is Director, NABL having responsibility for heading operations(Testing). She has more than 20 years of experience of with NABL

 $She\ has\ done\ her\ post\ graduation\ in\ Energy\ and\ Environmental\ Management\ from\ IIT\ Delhi\ .$ 

She is APAC Lead evaluator and lead assessor for testing. She is also memyber in technical committees of variousOrganisations like' BIS and CPCB, MNRE.





# "NABL Accreditation delivering confidence to NDT Laboratories"

Ms. Anuja Anand Director , NABL

THE ABSTRACT

National Accreditation Board for Testing and Calibration Laboratories (NABL) is an accreditation body, with its accreditation system established in accordance with ISO/ IEC 17011. NABL provides voluntary accreditation services to testing (ISO/IEC 17025), calibration(ISO/IEC 17025), medical (ISO 15189), Proficiency Testing providers (ISO/IEC 17043) and Reference Material producers (ISO 17034).

NABL is Mutual Recognition Arrangements (MRA) signatory to ILAC as well as APAC. Such MRA reduces technical barrier to trade and facilitates acceptance of test/ calibration results between countries which MRA partners represent.

NABL has been established with the objective of providing Government, Industry Associations and Industry in general with a scheme of Conformity Assessment Body's accreditation which involves third-party assessment of the technical competence.

NABL offers accreditation services in a non-discriminatory manner. These services are accessible to all testing including medical and calibration laboratories, proficiency testing providers and reference material producers in India and other countries in the region, regardless of the size of the applicant CAB or its membership of any association or group or number of CABs already accredited by NABL.

Non-destructive testing (NDT) is a vital field that allows for the evaluation of materials, components, and systems without causing harm or disruption. These innovative techniques are key to maintaining safety, reliability, and efficiency in industries such as aerospace, construction, manufacturing, and energy. By employing methods like radiographic testing, ultrasonic testing, and electromagnetic testing, NDT professionals can detect flaws, prevent failures, and ensure the longevity of critical assets.NABL is offering services by providing accreditation in the area of Non-destructive testing to the laboratories as per ISO/IEC 17025: 2017 to cater the needs of the industry.

The topic covers about the NABL accreditation and how NABL accreditation delivers the confidence to NDT labs with focus on benefits of accreditation, accreditation process and requirements related to Non-destructive testing, proficiency testing and present status of accredited laboratories along with the ways to search accredited laboratories on NABL website and How to apply online for NABL accreditation.







**Dr. Zheng Fan**Nanyang Technological University, Singapore

Dr. Zheng Fan is an associate professor in the School of Mechanical and Aerospace Engineering at Nanyang Technological University, Singapore. He earned his Ph.D. degree in Mechanical Engineering from Imperial College London in 2010, and his Bachelor's and Master's degrees in Acoustics from Nanjing University in 2004 and 2006, respectively. Currently, he leads a research team dedicated to developing novel techniques for the non-destructive evaluation, structural health monitoring, and sound manipulation. His work integrates advanced physics and modeling techniques with the development of technologies that can be rapidly deployed in practical settings.Dr. Fan maintains strong links with the global industry, collaborating with major companies such as Rolls-Royce, Shell, Lloyd's Register, EDF, and Sembcorp, etc. His research spans from thorough investigations of fundamental theories to the application of science in addressing real-world challenges. The results of his work have been published in over 80 papers in top tier journals. He holds two international patents and has successfully licensed these technologies to industry partners. In 2018, Dr. Fan was awarded the Achenbach Medal for his outstanding contributions to structural health monitoring. Heis ranked among the world's top 2% of scientists by Stanford University. Dr. Fan also serves as an Associate Editor for "Structural Health Monitoring – An International Journal" and "Ultrasonics," two leading journals in his field.





## Detection of Early-Stage Corrosion in Reinforced Concreteusing Ultrasonic and Electromagnetic Methods

Weixia Cheng<sup>a</sup>, Hai-Han Sun<sup>b</sup>, and Zheng Fan<sup>c</sup>

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THE ABSTRACT

Corrosion of reinforcing bars is a critical factor in the degradation of reinforced concrete (RC) structures, leading to serious structural integrity issues. The expansion of corrosion products induces tensile stresses, causing the concrete cover to crack and spall, while the diminishing cross-sectional area of the reinforcing bars severely compromises the structure's load-bearing capabilities and bond strength. Hence, it is necessary to develop robust non-destructive evaluation methods to assess the corrosion damage at an early stage.

In this work, we propose the integration of both ultrasonic and electromagnetic approaches to identify initial signs of corrosion damage. Ultrasonic methods, renowned for their sensitivity to discrepancies in acoustic impedance, such as cracks and voids, are employed alongside electromagnetic techniques, which excel in detecting metallic structures due to marked differences in dielectric permittivity and conductivity. Specifically, the application of ultrasonic coda wave interferometry and Rayleigh wave spectroscopy offers the opportunity to track the progression of internal cracks within reinforcing bars. Concurrently, a linear multiple-input-multiple-output (MIMO) Ground Penetrating Radar (GPR) array is utilized to visualize the reinforcing bars within concrete. This method excels in the early stages of corrosion, where rust formation and the inception of small cracks result in noticeable alterations in the GPR images. Additionally, a wideband dual-polarized GPR system is also investigated to capture the signal changes due to early corrosion damage. The efficacy of the proposed ultrasonic and electromagnetic methods has been validated through experimental work with accelerated corrosion in the laboratory.

Keywords: reinforced concrete, ultrasound, electromagnetic, early-stage corrosion







### **Dr Herbert Wiggenhauser**

Consultant in NDT in Civil Engineering

Physicist, graduated 1986 at Technical University Berlin/Germany. PostDoc at Lash-Miller-Laboratory at University of Toronto Canada (1986/87)

Director of Section NDT in Civil Engineering at BAM (Federal Institute for Materials Research and Testing) in Berlin/Germany between 1989 and 2018.

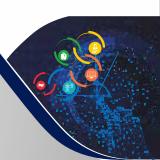
Involved in numerous national and international research projects on the development of NDT&E methods: LIBS Laser Induced Breakdown Spectroscopy; Ultrasonic Pulse Echo for Concrete; Radar for Concrete and Masonry; Scanning Impact-Echo; IR Thermography (transient); Moisture Measurements in Concrete and Masonry; Optical surface scanning; Statistical methods; Data analysis (time-frequency analysis, adaptive filtering); Distributed sensor networks for concrete structures; Corrosion identification with GPR

Application of methods: Testing of bridges; Automation of methods; Combined methods (data fusion); Testing of historical structures;Information, Education, Standards; Validation; Reference specimens Guest scientist at CSIR-SERC (Structural Engineering Research Centre, Chennai) within Humboldt Reciprocity Research Award 2006

Past member and chairman of national and international committees (DGZfP, TRB, ACI) Organizer of NDT-CE 1995,2003 and 2015 in Berlin/Germany and other national conferences and workshops.

Since retirement consultant in NDT in Civil Engineering.





# Data Management in Ultrasonic Assessment of Concrete Structures

Dr. Herbert Wiggenhauser Consultant in NDT in Civil Engineering

THE ABSTRACT

Ultrasonic Assessment of concrete structures has become a success story in Nondestructive Testing in Civil Engineering. Thanks to the industrial development of ultrasonic shear wave arrays and powerful analysis software, testing concrete structures for flaws or to ensure the quality of construction has become a reliable practice in the construction business.

An enormous amount of data is collected over time, improving the experience of operators and contributing to a large data repository for the validation of data analysis and interpretation. The link between the structure under investigation so far is left to individual procedures, based on operator notes and file system storage.

A web based data management system is presented which simplifies the documentation of tests on a structure and to combine test object, test protocol, and test results. Safe information sharing between anybody involved in the test is intrinsic to the system, thanks to the web based implementation.





Dr. Marc Kreutzbruck
Institut für Kunststofftechnik,
Universität Stuttgart, Germany

Physics diploma in superconducting magnetic field sensors in 1995 and Ph.D in 1998 using SQUID in Eddy Current Testing. Assistant Professor at the Institute of Applied Physics at the University of Giessen, and 2007 head of the former NDT division 8.4, BAM Berlin focusing acoustic, electromagnetic and thermal testing methods. Since 2014 full professor and chair for Nondestructive Testing at the University of Stuttgart, Germany with research in the field of production and quality assurance of plastics and composites. Heading the Institute of Plastic Technology (IKT) and chairing many NDT-related advisory boards and technical committee. Author and co-author of more than 300 publications and currently spending a half-year sabbatical at the CEA-NDT department in Paris, France.





# Manual Inspection or R2-D2? - Robotics and AI boosting the trend towards fully automated NDT

Marc Kreutzbruck
Institut für Kunststofftechnik, Universität Stuttgart, Germany

THE ABSTRACT

As with many other areas of technology, nondestructive testing is currently undergoing a shift towards a higher level of automation. This includes not only the trend towards the use of more robotics, but also the entire signal processing chain, imaging and characterization algorithms, and the final interpretation to evaluate the actual component condition. Both the omnipresent cost pressure in quality assurance and the shortage of qualified inspectors in many industries support the trend towards machine-based inspection processes. The current rapid progress in the field of artificial intelligence will additionally massively accelerate this change.

As an example, the presentation will show a fully automated and flexibly positionable NDT dual robot platform that can inspect components with a size of up to 12 m<sup>2</sup>. Integrated tool changers enable the use of several simultaneous or serial inspection processes. In order to operate a variety of different NDT processes, the individual robots are laser calibrated and achieve a path accuracy of approximately 100  $\mu$ m. The robots are mounted on freely movable platforms and can be moved on air cushions despite their weight of over 4 tons. The required registration of the two NDT tool centers into the laboratory coordinate system is therefore performed by an additionally operating laser system. The possibilities and limitations of machine automation are illustrated using the example of air-coupled ultrasonic testing. In addition to automated hardware, it will also be shown how complex data sets can be automatically evaluated to determine material parameters in composites such as fiber lengths and orientations or pore contents. This includes the use of nonlinear UT to test adhesive bonds for kissing bonds. One of the key challenges of non-destructive testing is the transfer of test data into a true picture of the component's condition. Usually, this requires solving a classical inverse problem. While numerous solvers exist for CT, methods such as thermography are only at the beginning of the development of complete inverse 3D solutions. Using the example of active thermography, the presentation highlights how precise defect geometries and defect depths can be represented by means of AI, thus achieving a significantly increased informative value compared to conventional readout algorithms. The presentation highlights how the combination of robotics and AI as two key technologies will significantly improve the degree of automation.



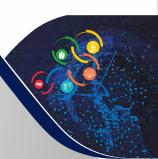




**Prof. Lalita Udpa**Michigan State University, USA

Lalita Udpa received her Ph.D. in Electrical Engineering from Colorado State University. There after she served for over a decade in the department of Electrical and Computer Engineering at Iowa State University. She is currently a University Distinguished Professor in the department of Electrical and Computer Engineering at Michigan State University. Dr. Udpa works primarily in the broad areas of Nondestructive Evaluation, Signal Processing and Analysis. Her research interests include various aspects of NDE such as development of computational models and its use in new sensor design, signal and image processing, data fusion, and inverse problem solutions. She has been recognized by several awards; Distinguished Scholarship award at Michigan State University, the ASNT Sustained Research Excellence Award and the ASNT award for Advancement of Women in NDT. Dr. Udpa is a Fellow of the IEEE and a Fellow of the American Society of Nondestructive Testing and Indian Society of Nondestructive Testing. She served as associate technical editor of Research Techniques in NDE and as an editor of IEEE Transactions on Magnetics.





## Multi-modal, in-motion rail damage detection and characterization

Yiming Deng, Sunil Chakrapani and Lalita Udpa Department of Electrical and Computer Engineering, Michigan State University 428 S. Shaw Ln, East Lansing, Michigan, 48824, USA THE ABSTRACT

Rail tracks are subjected to intense bending and shear stresses, plastic deformation and wear, leading to degradation of their structural integrity with time. A variety of damage modes exist in rails, and one of the most recurring problem is the fatigue crack in the wheel-to-rail contact thread, which is generated by stressing the material with cycles of thermal and mechanical loads. Although the microstructural damage might not appear to be catastrophic at its initial stage, dangerous rolling contact fatigue (RCF) modes can develop as macro-structural defects propagate and crack the rail into failure if prompt detection and maintenance are not properly performed.

Considering the vast extent of the rail network, there is need for high speed and reliable inspection systems. This talk describes work that is being carried out at Michigan State University on innovative multimodal NDT for RCF detection and characterization. The proposed system offers non-contact high-speed inspection of RCF damage in rails. The multi-modal probe combines ultrasonic testing (UT) using surface Rayleigh waves generated and detected using electromagnetic acoustic transducers (EMAT), electromagnetic testing that includes magnetic flux leakage (MFL) as well as motion-induced eddy current (MIEC) sensors. Data from these modalities are combined using appropriate data fusion strategies to reliably detect, locate and characterize RCF damage.

The UT sensing module generates a 1 MHz Rayleigh surface waves for surfaceand near-surface inspection of rails. While the UT module exhibits excellent damage detection capabilities, the EMAT's large sensing footprint hinders high-resolution defect localization. The EM module then provides high-resolution defect localization potential due to the small footprint of the hall sensor. Further, MIEC sensing is shown to offer significant potential for damage characterization since the sensitivity increases with increase in inspection speed, which is well suited for in-motion inspection.

Finally, a data fusion module is proposed which integrates the UT module's strong defect detection capabilities and the EM module's localization capabilities to produce a reliable spatial probability density function (PDF) that quantifies the probability that any given spatial location will contain a defect.

An experimental rail testing setup is beingdeveloped where themultimodal probe and the associated instrumentation is fixed to a rail cart which can be moved while carrying out a multi-modal inspection.

**Keywords:** hybrid probe, ultrasonic testing, motion-induced eddy current, RCF damage, in-motion inspection

Acknowledgement: The work reported in the paper was performed with funding from the Association of American Railroads (AAR) Strategic Research Initiative(SRI) University programs and MxV Rails. The authors would like to thank AAR and itsmembers for their funding support, as well as the Project Manager Dr. Anish Poudel and his team for technical guidance and support.





### Prof. Prabhu Rajagopal

**IIT-Madras** 

Trained at IIT Madras (BTech & DD MTech) and Imperial College London (PhD, Postdoc), Prof. Prabhu Rajagopal has expertise in Nondestructive Evaluation (NDE) and Structural Health Monitoring (SHM), coleading the Center for NDE. With over 30 funded projects, 200+ technical articles and 33 granted IPs, he is widely recognised for his pioneering work on remote inspection technologies for digital transformation in the industrial (energy and mobility) and social (water, health and sanitation) contexts. He is recipient of India's most prestigious award for mid-career scientists, the Shanti Swarup Bhatnagar prize under the category of Technology and Innovation (2024). Prof Prabhu's research is collaborative, cross-disciplinary and international, with ongoing engagements with industry and academic institutions across the world; particularly the UK and Kenya. At IIT Madras he is also a founding member of the Centers of Excellence in Quantum Information Communication & Computing, Cybersecurity, Trust & Reliability, and Space Manufacturing, as well as the one on Research on Startups & Risk Financing.

Prof. Prabhu is passionate about service-oriented engineering education and technology translation, co-founding several Startups that are disrupting the infrastructure maintenance space with their original offerings in digital asset integrity monitoring. Today, river crossings of rail and road bridges, and distribution water pipes are inspected across India and several locations in the world by Planys and Solinas. Planys also has a suite of robotic solutions for online inspections of storage tanks and marine drones for rapid waterbody assessments. Xyma develops waveguide ultrasonic sensors for maintenance of large industrial plants, applied across mineral ore processing, petrochemical and glass industries. More recently, Plenome focuses on secure management of personal health records.

Recipient of prestigious Early Career awards (National Design Award from Institution of Engineers (India), National Young Scientist Awards from: Indian Society for NDT and Institute for Smart Structures and Systems, Institute R&D Award from IIT Madras \( \)and the National Swarnajayanti Fellowship from DST, Govt of India), Prof. Prabhu is member of the Editorial Boards of international peer-reviewed journals, Ultrasonics\( \) and NDT&E International. At IIT Madras, he is the faculty in-charge of the maker space Center for Innovation and the pre-incubator Nirmaan.\( \) He is on the Advisory Board of the Techin\( \), the Incubator of IIT Palakkad, as well as serving on their Global Sanitation Center of Excellence. Prof. Prabhu's work has also been featured widely in popular media.





## "Automation & Data Engineering in NDE and Beyond"

Prof. Prabhu Rajagopal IIT-Madras

THE ABSTRACT

his talk will give an overview of innovations and advances in automation for NDE of infrastructural assets and also cover aspects of data management insight generation. The context and motivation for the work within the relevant sectors, such as power generation, transport oil & gas and water & sanitation networks will be given. Key challenges and their solution leveraging principles of modern design as well as advances in information and communication technologies will be covered. A couple of example use cases illustrating the application of artificial intelligence, quantum computing and distributed legdger technologies augmenting core innovations in NDE methodologies will be presented. Insights on leveraging start-up and MSME partners in taking such innovations to the field will be shared. Finally, some directions for further work and implications for the field will be discussed.







**Dr. Sajeesh Babu**Director, Rotary Group,
CEO, ANSA Holdings, Singapore

Dr. Sajeesh BABU has 30 years of International Experience in Energy, Refineries & Petrochemical, Oil & Gas, Building & Construction Industry in Quality Assurance & Control, NDT, Condition Monitoring & Diagnostics Testing,

Currently he is holding a position of Quality Director in Rotary Group & CEO of ANSA Holdings, Singapore

He is currently the Chairman of the International Committee for NDT (ICNDT), Vienna & the President of Non-Destructive Testing Society (Singapore).

He worked greatly for the promotion of harmonization in NDT personnel certification worldwide in specific to ISO 9712 standards

Dr. Babu obtained his Engineering Doctorate from City University of Hong Kong and obtained his Master of Engineering from University of South Australia. His research includes Reliability & productivity of Non-Destructive testing in constructions welds under Systems Engineering.

He is a Chartered Engineer from Singapore &UK & Registered Professional Engineer from HK respectively. He is a Qualified ISO9712 NDT Level 3& ASNT NDT Level 3

He is a fellow of HKICA, fellow of NDTSS, Honorary member of ICNDT & APFNDT.





# NDT Personnel Certification Trends & Harmonization, How do your recognize the needs of personnel certification in your Industry

THE ABSTRACT

Dr. Sajeesh Babu Director, Rotary Group, CEO, ANSA Holdings, Singapore

As with many other areas of technology, nondestructive testing is currently undergoing a shift towards a higher level of automation. This includes not only the trend towards the use of more robotics, but also the entire signal processing chain, imaging and characterization algorithms, and the final interpretation to evaluate the actual component condition. Both the omnipresent cost pressure in quality assurance and the shortage of qualified inspectors in many industries support the trend towards machine-based inspection processes. The current rapid progress in the field of artificial intelligence will additionally massively accelerate this change.

As an example, the presentation will show a fully automated and flexibly positionable NDT dual robot platform that can inspect components with a size of up to 12 m<sup>2</sup>. Integrated tool changers enable the use of several simultaneous or serial inspection processes. In order to operate a variety of different NDT processes, the individual robots are laser calibrated and achieve a path accuracy of approximately 100  $\mu$ m. The robots are mounted on freely movable platforms and can be moved on air cushions despite their weight of over 4 tons. The required registration of the two NDT tool centers into the laboratory coordinate system is therefore performed by an additionally operating laser system. The possibilities and limitations of machine automation are illustrated using the example of air-coupled ultrasonic testing. In addition to automated hardware, it will also be shown how complex data sets can be automatically evaluated to determine material parameters in composites such as fiber lengths and orientations or pore contents. This includes the use of nonlinear UT to test adhesive bonds for kissing bonds. One of the key challenges of non-destructive testing is the transfer of test data into a true picture of the component's condition. Usually, this requires solving a classical inverse problem. While numerous solvers exist for CT, methods such as thermography are only at the beginning of the development of complete inverse 3D solutions. Using the example of active thermography, the presentation highlights how precise defect geometries and defect depths can be represented by means of AI, thus achieving a significantly increased informative value compared to conventional readout algorithms. The presentation highlights how the combination of robotics and AI as two key technologies will significantly improve the degree of automation.









#### **CURRENT POSITIONS**

Vice President, Indian Society of Nondestructive Testing (ISNT) Co-Founder and Chief Scientific Officer, Azeriri Pvt Ltd, Chennai Mentor, TeraLumen Solutions Ltd, Chennai Co-Founder, nAurava LLC, USA Co-Founder, InMatIn, Bangalore Professional Director, Pallakki NDT Excellence Centre, Bangalore Principal Consultant, Innomantra Consulting Pvt Ltd, Bangalore Technical Advisor, National Research and Design Forum, Bangalore Professor-of-Practice, VELTECH, Chennai Member, Research Advisory Board, Ramaiah Institute of Technology, Bangalore Former Principal Scientist / Quality & Innovation Leader at GE Global Research (2000 to 2020) Former Senior Scientific Officer @IGCAR, Kalpakkam (1984 to 2000) Certified Lean Six Sigma Black Belt, TRIZ Level 3 expert, ASNT NDT Level 3 (ET & MT).

A B.E (Metallurgy) from MS University Baroda and a Ph.D from IIT, Kharagpur, he is a 40 years experienced innovator, researcher, technologist and trainer with deep domain expertise in the multidisciplinary area of Nondestructive Evaluation (NDE) of materials, components and structures as applied to Aerospace, Oil & Gas, Power, Nuclear, Renewables, Transportation and other industries. Having worked at two premier institutions – IGCAR, Kalpakkam and GE Research, Bangalore during his entire career, his passion lies in synergizing between domains and adjacencies to enable best-in-class solutions for challenging industrial problems. He has worked on some of the most advanced techniques in Electromagnetic, Ultrasound, Infrared Imaging and Radiographic NDE, and utilized Automation, Analytics and Robotics/Drones for Industrial Inspection. Focus of his work was in the conceptualization, innovation, development, and transition of novel and Advanced NDE / Inspection techniques from laboratory to the factory shopfloor and other field and plant environments. This enabled better quality control, in-service inspections, structural integrity, and residual life assessments.

Post his retirement from GE, he is engaged in mentoring, advising, and consulting with several deep tech start-ups and MSMEs focusing on advanced NDE including Digital Radiography, Air-coupled Ultrasound, Microwave, Terahertz, and others. He is pioneering the adoption of NDE 4.0 (a subset of Industry 4.0) and Inspection through digitalization and digital transformation (IoT, Digital Twins, AR/VR, Analytics using AI and ML, AR/VR, etc). He is passionate about Industry-Academia interactions and is trying to help promote NDE as a potential career opportunity amongst the younger generation.

He has 14 US patents and 200+ papers in various journals, books and proceedings and has delivered 100+ invited talks. Received several prestigious awards like ISNT National NDT award for R&D, GE India's JRD Tata award for excellence, GE Whitney award to name a few. He is an Honorary Fellow of ISNT and a Life Member of ASNT, MSI, AMSI, InSIS. He is on the Editorial Board of ISNT's Journal of NDE and a Reviewer for several other international journals.





## Data to Decision through Digitalization: Trending paradigm in NDE

Dr. Shyamsunder Mandayam

THE ABSTRACT

The Industrial world with its numerous manufacturing / process plants and utilities are always working towards ensuring performance, efficiency, productivity, integrity, safety, and reliability. Operators and asset owners need toensure that the plants deliver the required functions and performance in a sustainable mannerand avoid unplanned downtime and the associated safety and environmental incidents. NDE and Inspection have a prominent and unique role to play in the entire lifecycle of a component / structure / plant / product. However, some of the biggest transformations and trends for the future are emerging in the form of greater developments and adoption of Industry 4.0 over the next few years. The specific developments as applied to the world of NDE/Inspection and its adjacencies is now popularly termed NDE 4.0. This talk will highlight the key attributes of NDE 4.0 including digitalization through the use of IIoT, Robotics/Drones, Digital twins, Cloud computingand storage, Artificial intelligence, Machine learning, Augmented/Virtual reality, etc and how it has the potential to drastically change the scenario in the coming decade. In today's fast-evolving digital landscape, organizations face both unprecedented opportunities and challenges in transforming vast amounts of data into actionable insights. The digitalization of decisionmaking processes enables businesses to leverage data at every level, making strategic and operational choices with greater accuracy, speed, and confidence. Digitalization also encompasses the integration of Al-driven decision support systems, which aid in processing and interpreting data at a scale beyond human capabilities. These systems identify correlations and make recommendations, enabling leaders to anticipate changes and make proactive decisions. Machine learning algorithms refine decision-making over time by continuously learning from new data, thus enhancing predictive accuracy, and enabling realtime adjustments to strategies and operations. However, digitalized decision-making also requires addressing challenges related to data formats, quality, storage, privacy, security, and organizational acceptance. The rapid advancements in digital technologies have catalyzed a paradigm shift in Non-Destructive Evaluation (NDE), transforming traditional inspection processes into data-driven decisionmaking frameworks. Digitalization enables NDE systems to move beyond isolated inspections by integrating real-time data acquisition, predictive analytics, and intelligent decision-making into a seamless workflow. Sensors embedded in critical infrastructure continuously collect high-resolution data, while Al algorithms identify anomalies, classify defects, and predict failure risks with unprecedented precision. This approach significantly enhances reliability, reduces inspection times, and ensures compliance with stringent safety and quality standards across industries such as aerospace, nuclear, oil and gas, and transportation. The talk will delve into key trends driving this transformation, including automated defect detection, cloud-based data sharing, and the use of digital twins to simulate and analyze structural performance. Practical case studies will illustrate the benefits of this paradigm, such as improved quality control, operational efficiency, reduced downtime, and increased safety in high-stakes environments. By harnessing digitalization, NDE evolves into a strategic asset, enabling industries to transition from reactive maintenance to predictive and proactive approaches. This trending paradigm is not merely a technological upgrade but a fundamental shift in how NDE is practiced, aligning with Industry 4.0 principles. The talk concludes by examining the future potential of digital NDE, emphasizing its role as a transformative force in ensuring structural integrity, safety, and operational excellence in the industrial world.





# INVITED TALKSSCIENTIFIC

34th
Annual Conference & Exhibition on
NON DESTRUCTIVE
EVALUATION & ENABLING
TECHNOLOGIES

DEC 12-14, 2024 • CHENNAI





**Dr. Andrey Bulavinov**Merkinger STR. 21,

#### **Career Objective**

Conceptual Design, Development and Marketing of High-end Quality Testing Instruments, Systems and NDT Techniques for Industrial Applications.

13.12.1975 BORN IN NOWAJA LJALJA, SVERDLOVSK-REGION, RUSSIA

66119 Saarbrücken

**GermaNY** 

#### **EDUCATION**

19.02.1999

01.08.1997 - 28.09.1999

01.09.1983 – 31.05.1992 MIDDLE SCHOOL NO. 2, NOVAJA LJALJA 07.09.1992 – 01.07.1993 MIDDLE SCHOOL NO. 4, NOVAJA LJALJA

GRADUATION WITH SILVER MEDAL 01.08.1993 – 19.02.1999

STUDY AT THE URAL STATE TECHNICAL UNIVERSITY,

PHYSICAL-TECHNICAL FACULTY, CHAIR OF

NON-DESTRUCTIVE TESTING, EKATERINBURG, RUSSIA

01.08.1998 – 19.02.1999 WRITING AND DEFENCE OF MASTER THESIS

"COMPREHENSIVE ANALYSIS OF MAGNETIC PROPERTIES OF HEAT TREATED STEELS" PASSED WITH NOTE "EXCELLENT" GRADUATION / QUALIFICATION "ENGINEER-PHYSICIST"

JUNIOR SCIENTIST IN THE INSTITUTE FOR METAL PHYSICS, EKATERINBURG, RUSSIA

28.09.1999 – 28.12.1999 PRACTICUM AT THE FRAUNHOFER-INSTITUTE FOR

NON-DESTRUCTIVE TESTING IZFP, SAARBRÜCKEN,

GERMANY. SUBJECT: AUTOMATIC ULTRASONIC INSPECTION

15.09.2000 – 15.09.2005 PHD STUDENT AT THE FRAUNHOFER-IZFP,

SAARBRÜCKEN, TOPIC OF PHD THESIS:

"SAMPLING PHASED ARRAY"

03.11.2005 DOCTOR OF ENGINEERING (MATERIAL SCIENCE) AT

UNIVERSITY OF SAARLAND PASSED WITH NOTE

"MAGNA CUM LAUDE"

**EMPLOYMENT** 

15.09.2005 – 30.04.2014 GUEST SCIENTIST / POSTDOCTORATE / GROUP LEADER FOR

ULTRASONIC TESTING AT THE FRAUNHOFER-IZFP,

SAARBRÜCKEN

SINCE 21.01.2009 FOUNDER AND CEO AT I-DEAL TECHNOLOGIES GMBH

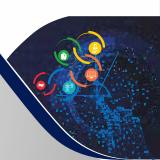
(SPIN-OFF COMPANY OF FRAUNHOFER-IZFP)

SINCE 04.01.2017 CEO AND MANAGING DIRECTOR AT ACOUSTIC CONTROL

SYSTEMS - ACS-SOLUTIONS GMBH AND I-DEAL

**TECHNOLOGIES GMBH** 





IT 01

THE ABSTRACT

## Novel trends in the ultrasonic imaging for non-destructive material evaluation: quantitative, automated, real-time

Andrey Bulavinov, Roman Pinchuk, Andrey Samokrutov Acoustic Control Systems - ACS-Group, Germany

Recent advancements in ultrasonic imaging have significantly enhanced non-destructive material evaluation capabilities, in particular by means of ultrasonic tomography, especially in industries such as metal forging, composite materials, and concrete in civil engineering. This contribution explores novel trends in ultrasonic tomography, emphasizing its role in providing quantitative, automated, and real-time inspection capabilities. The integration of two- and three-dimensional evaluation methods has enabled quantitative characterization of internal defects, material properties, and structural integrity, offering essential insights for quality assurance. Automation and the use of robotics in ultrasonic testing have further advanced the evaluation of complex-shaped parts, ensuring consistent and accurate assessments even in challenging geometries. These innovations are crucial for improving safety, reliability, and performance in industrial applications. The contribution delves into the latest technological developments, discusses application case from relevant industries, and outlines future directions for ultrasonic imaging in non-destructive material evaluation.

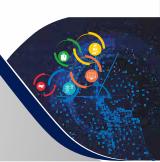




Hajo Schulenburg
VisiCOnsult Germany

Hajo Schulenburg is currently General Manager of VisiConsult X-ray Systems & Solutions GmbH, Germany, and Director of VisiConsult Private Limited, Pune. He has more than 35 years of experience in the manufacturing of x-ray inspection systems. He started his career as a Chip designer at Philips. Later moved to NordischerMaschinenbauas a development engineer. He was working on the development of the fishbone X-ray scanner. He was Head of software at SEIVERT for more than 10 years, developingVistaplus and SABA software for x-ray inspection. He founded VisiConsult x-ray systems & solutions in 1996. He contributed to the development of Xplus - x-ray inspection & control software and differentiated the company by offering customized inspection solutions. He started a manufacturing facility in Pune and contribute to the cost-effective x-ray systems, called the ECO series.





## Industrial 4.0 – NDT 4.0 – AI – Is this enough to have a good X-ray system?

IT 02

THE ABSTRACT

Hajo Schulenburg VisiCOnsult Germany

Industrial 4.0-NDT 4.0-Al - This today's buzzwords make us believe that the use of one or all of this technology trends will solve all our problems we have in the field of NDT. For sure allof them are important or will be important in future. But we should keep in mind that a good designed machine, optimized process flow and good educated employees are necessary to have a successful NDT solution. A onetime investment in a NDT test solution is only worth when we invest in the same time in people. At the end the Level 2/3 needs to validate the results and the reliability of the method. The presentation will guide you through the process of having a new NDT ( xray ) solution. ROI calculations and also management recommendations are part of the presentation.





M.R.Vijaya Lakshmi Scientist, DRDO

Certification in accordance with the American Society for Nondestructive Testing (ASNT) as per SNT -TC-1A guidelines as NDT Level III in Radiographic Testing (RT), Ultrasonic Testing (UT), Magnetic Particle Testing (MT) and Penetrant Testing (PT).

Certified as ISO 9001: 2015 Series Auditor/Lead Auditor

#### **Professional Summary**

Over 23 years of experience in the field of Non-Destructive Evaluation of metallic and composite hardware for various DRDO (Defence Research and Development Organisation) projects.

#### Education

B.Tech. in Mechanical Engineering and M.Sc. (engg.) – Mech Engg.

#### **Experience Summary**

Working as Scientist in Gas Turbine Research Establishment (GTRE), Bangalore (DRDO laboratory) since February 2006.

Worked as Scientist in Defence Research and Development Laboratory (DRDL), Hyderabad (DRDO laboratory) from March 2001 to January 2006.

#### Memberships

- Life Member, Indian Society for Nondestructive Testing (ISNT)
- Member, American Society for Nondestructive Testing (ASNT)
- Life Member, Aeronautical Society of India (AeSI)
- Life Member, SFA

#### Awards & Achievements

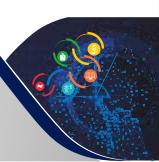
Received DRDO National Technology Day Award 2004

DRDO National Science Day Award 2011 DRDO commendation certificate 2023

Papers Published

20 National 02 International





## Role o Non-Destructive Evaluation (NDE) for Damage Tolerant Design

IT 03

M.R.Vijaya Lakshmi Scientist, DRDO THE ABSTRACT

Damage tolerance, as its name suggests, entails allowing subcritical flaws to remain in a structure. These flaws can be on the surface or within the thickness of the material. Repairing flawed material or scrapping a flawed structure is expensive and is often unnecessary. Fracture mechanics provides a rational basis for establishing flaw tolerance limits.

Consider a flaw in a structure that grows with time (e.g.; a fatigue or a stress corrosion crack). The initial crack size is inferred from NDE and the critical crack size is inferred from the applied stress and fracture toughness.

Normally, an allowable flaw size would be defined by dividing the critical size by a safety factor. The predicted service life of the structure can then be inferred by calculating the time required for the flaw to grow from its initial size to the maximum allowable size.

The NDE provides input to the fracture analysis, which in turn helps to define inspection intervals. A structure is inspected at the beginning of its life to determine the size of initial flaws. The main purpose of damage tolerance assessment is to ensure that flaws will not grow to failure between inspections. Surface flaws can be evaluated by Fluorescent Penetrant Testing (as the materials are non-magnetic). Additionally, Eddy Current Testing can also be used to determine the depth of the flaw.

Internal flaws have to be evaluated by Ultrasonic Testing (as the raw materials are in forged condition. However, flaws existing in all possible directions have to be detected to provide confidence of inspection. Suitable techniques, probes have to be selected and scan plans have to be generated. Flaw size can be estimated with assumption of error factor. As for now, 0.4 mm size internal flaws can be detected with 90% confidence in planar direction. This can be set as the initial assumed flaw size to be already present in the material. Flaws 0.4mm present in all directions will be detected and sized. Further, inspection has to be carried out at regular intervals to inspect for the flaw growth and a curve will be generated.







**Dr. David Alleyne** 

David Alleyne is the CEO of GUL, and was a co-founder of the company in 1998. He holds a PhD in Mechanical Engineering from Imperial College London. His research at Imperial from 1987 addressed the exploitation of Lamb waves for the NDT of plate structures, followed by the pioneering foundational research on the guided wave testing of pipes. He has authored patents relating to guided wave testing equipment and was pivotal in the creation of the guided wave testing methodology, codes, standards and Level 3 certification. He has been the driver for the global commercialisation of guided wave NDT and monitoring methods and is the acknowledged world leader in the industrial application of this technology. David leads all aspects of the business and has responsibility for the strategic vision and direction of the company. He has gained a wealth of invaluable experience from partners and clients from every corner of the world, which is reflected in the diverse and talented group of people within GUL and the emphasis placed on team work, quality, customer needs and innovation. He is a director of ASNT





## Guided Wave Testing over the last 4 decades

Dr. David Alleyne GUL **IT 04** 

THE ABSTRACT

In this presentation, we will discuss the development road-map over the last four decades that led to the latest advances in guided wave testing (GWT), which can now provide high-accuracy wall thickness measurements and long-range rapid screening or monitoring. Guided waves have a significant advantage of allowing for the inspection of a large volume of a structure from a single remote location. We will discuss how GWT has evolved from university laboratory experiments and theoretical advances to become an established testing method globally. The method has provided new integrity solutions mostly for pipelines Today guided waves are used for a myriad of inspection solutions some of which will be used to illustrate salient points. This presentation will discuss how the author has been involved in the journey of the development of the theory and application of guided wave testing and monitoring and pointing towards a future involving digitisation and automation.



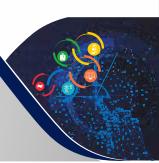




**Esha Sen Gupta**Senior Scientist
GE Aerospace Research

Esha Sen Gupta is presently working in GE Aerospace Research as a Senior Scientist in the Material Systems and Inspection team. Graduated with a master's in physics and PhD from Max Planck Institute, Germany in the field of material science and characterization and a post-doctoral fellowship from the university of Washington. An experimental physicist engaged in the multidisciplinary areas of electromagnetics, optics, radiation physics and magnetic measurements. Devised state of the art, innovative technologies for industrial NDE solutions using simulations, experiments, and analytics.





## From X-rays to THz: The Evolution of Aerospace Inspection

**IT 05** 

**THE ABSTRACT** 

Esha Sen Gupta Senior Scientist GE Aerospace Research

Non-destructive Evaluation (NDE) plays a pivotal role in ensuring the safety, reliability, and longevity of aerospace components and structures. This talk will provide a comprehensive overview of both traditional and emerging NDE technologies utilized within the aerospace industry. We will begin by exploring well-established methods such as X-ray radiography, which has been a cornerstone in defect detection and material characterization and the latest trends in the field. The discussion will then transition to cutting-edge advancements, with a particular focus on Terahertz (THz) inspection techniques. These innovative approaches offer promising capabilities for detecting subsurface anomalies and assessing material properties with high precision. By comparing the strengths and limitations of these technologies, we aim to highlight the evolving landscape of NDE and its critical impact on aerospace safety and performance.







Dr. Ik-Keun Park

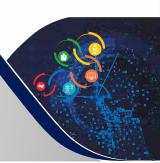
NDT Research Center, Seoul National University of
Science and Technology(SeoulTech), 232 Gongneung-ro,

Dr. Ik-Keun Park is currently serving as an Emeritus Chair Professor in the NDT Research Center at the Seoul National University of Technology(SeoulTech). Prof. Park served as the President of KSNT(Korea Society for Nondestructive Testing) and the Chair and Co-Chair of 20th WCNDT and was leading high-tech NDT R&D projects in Korea.Recently, he has been serving as a regional director for APFNDT(Asia Pacific Federation for Nondestructive Testing).

Nowon-gu, Seoul 01811, Republic of Korea

His B.S and M.S degree is in Mechanical Engineering from Hanyang University. He completed his PhD in Precision Mechanical Engineering from Hanyang University, South Korea, in 1991, and joined the Ultrasonics Research and Development Lab. at PennState University in USA. His major field of research is the materials characterization and structural health monitoring with ultrasonic Non-destructive evaluation, and recently he has been very interested in the development of simulation-based phased array UT(PAUT) demonstration technology





# Development of Simulation-Based Phased Array UT(PAUT) Demonstration Technology-Improvement of Inspection Accessability and Replacement of RT with PAUT

IT 06

THE ABSTRACT

Dongchan Kang<sup>1</sup>, Sungjong Cho<sup>1</sup>, Dongryul Kwak<sup>2</sup>, Younglae Kim<sup>2</sup>, Ik Keun Park<sup>†,1</sup>

<sup>1</sup> NDT Research Center, Seoul National University of Science and Technology(SeoulTech), 232 Gongneung-ro, Nowon-gu, Seoul 01811, Republic of Korea, <sup>2</sup> KHNP Central Research Institute,

Tubes and piping within Korea's Thermal Power Plant Facilities operate in extreme environments (high temperature and pressure), making NDT(Non-Destructive Testing) essential to ensure reliability in terms of structural integrity. In the realm of NDT, a widely used method for evaluatingthe overall reliability(POD, Sizing) of inspection systems is the RRT(Round-Robin Test). However, a demonstration through RRT is based on experiments, and its extension and application to various industrial fields are subject to limitations owing to time and financial costs, such as test specimen production and infrastructure construction.

In contrast, for the European Network for Inspection & Qualification (ENIQ), a demonstration is performed using simulation in cases where it is difficult to construct test specimens for complex and diverse industrial facilities.

In this study, an ENIQ-Based Demonstration System is analyzed for the Thermal Power Plant Facilities in Korea. Furthermore, we aim to introduce ways to simulation modeling technology in the development of a simulation based Phased-Array Ultrasonic Testing (PAUT) Demonstration Technology for improving inspection accessibility and replacing RT with PAUT.

**Keywords:** Phased-Array UT(PAUT), Round-Robin Test(RRT), Reliability Analysis(POD, Sizing).

**Acknowledgment:** This work was supported by project for Korea Institute of Energy Technology Evaluation and Planning (KETEP\_(Grant No. 20217410100100), and KHNP Central Research Institute of Korea.





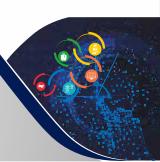


### S. Thirunavukkarasu

Nondestructive Evaluation Division, Materials Characterization Group, Metallurgy and Material Group, Indira Gandhi Centre for Atomic Research, Kalpakkam 603102, TN, India

Dr. S. Thirunavukkarasu completed his post-graduation in Physics from the American college affiliated to the Madurai Kamaraj University, Madurai in the year 1995. He joined as scientific officer in nondestructive evaluation division of Indira Gandhi Centre for atomic research Kalpakkam in the year 2000. His research interests include numerical modeling of electromagnetic NDE, signal, image processing and NDT systems development. He completed his doctoral thesis from Homi Bhabha National Institute (IGCAR) in the year 2015 for his work on the development of highly sensitive RFEC technique. He has over 50 technical publications in peer reviewed journals and 30 conference proceedings. He is being conferred the National NDT Award for Excellence in contribution to NDT Systems innovation & development for his outstanding contribution in the development of a field–worthy, modular high sensitive RFEC instrument. He is a recipient of DAE group achievement award two times. He is certified ASNT Level III in Electromagnetic NDE. He is actively involved in ISNT.





## Multi-NDE Inspection of Heat Exchanger Tubes

IT 07

S. Thirunavukkarasu, Arjun V., G.M.S.K. Chaitanya, B. Sasi, W. Sharatchandra Singh, A. Viswanath,

Tikesh Kumar Sahu, Anish Kumar

THE ABSTRACT

Nondestructive Evaluation Division, Materials Characterization Group, Metallurgy and Material Group, Indira Gandhi Centre for Atomic Research, Kalpakkam 603102, TN, India

Email: sta@igcar.gov.in

Structural Health Monitoring is an emerging technique which performs diagnosis and prognosis of structural health condition by combining advanced sensor technology with intelligent algorithms. From the aspect of total investment and preservation of constructional heritage, the non-destructive evaluation (NDE) techniques gained attention over past few decades in academia and industries. Eddy current, liquid penetrant, radiography, acoustic emission, ultrasonic testing are some of the well-known techniques, which come under non-destructive evaluation (NDE). Ultrasonic methods are the most active field of research in NDE because it has a great potential to detect very small sized damages (barely visible) caused by several factors like, fatigue, corrosion, porosity, creep, static/cyclic loading and unloading.

From past few decades, ultrasonic wave propagation methods (specially nonlinear ultrasonic methods-NLU) are found to be very promising in detecting wide range of damages. As, the pulses are of higher frequency (low wavelength), they can interact several times with the microcracks within the structure and bring out the maximum signature of the damage induced nonlinearities While interaction, the incident wave undergoes reflection, refraction, wave modulation, attenuation, phase transformation, wave diffusion, scattering and so on. Researchers perform several linear and nonlinear ultrasonic methods, such as, pulse velocity, attenuation, wavelet packet decomposition, Hilbert phase, diffusion, coda wave interferometry, nonlinear attenuation, scaling subtraction method, higher harmonic methods, sideband peak count, sideband energy ratio, energy based nonlinear acoustic parameter, pattern recognition methods to detect damage characteristics and the stress changes within the structure. This invited talk mainly focuses on three critical and unique aspects, 1) in depth microstructural study to address the wavematter interaction phenomenon, 2) critical damage condition monitoring and stress state evaluation in concrete structures that can help to carry out structural health monitoring for in-situ structures, and 3) the need of improvisation of existing ultrasonic methods, as well as, the establishment of advanced nonlinear ultrasonic methods to successfully monitor various critical damages and stress scenario.

**Keywords:** Nonlinear ultrasonics; Wave-matter interaction; Stress-induced damage; Interface flaw detection; Corrosion damage.







#### Gunasekaran R

Head, Radiography and Inspection Division (RID) VSSC, ISRO

Name: Gunasekaran R

Qualification: M. E in Production Engineering

Designation: Head, Radiography and Inspection Division (RID)

VSSC, ISRO

Academic Experience: 6 Years worked as Faculty in Department of

Mechanical Engineering, Engineering College

under Anna University.

Experience in ISRO:

Joined in Vikram Sarabhai Space Centre in Sep 1999. Contributed in Theoretical modelling and Simulation of Ordnance system in Space programmes. Developed and realized Separation system for RLV-TD.

15 years' experience in the area of NDT of Solid Propellant and Space Ordnance systems.

Established Neutron radiography facility, 9 MeV LINAC, Integrated 450 kV X-ray machine with Gantry based Manipulator and Integrated Dual Energy LINAC machine with Flat Panel Detector (FPD) with Manipulator.

Established a custom made Computed Tomography (CT) system utilizes Dual energy (3.5/6MeV) Linear accelerator (LINAC 3.5/6 MeV) and digital flat-panel detector (FPD) with flame-proof motor for Non-destructive imaging of Space Ordnance devices and systems for all our launch vehicles and satellites.

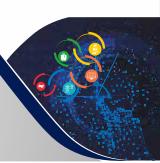
High Energy Materials Society of India (HEMSI) has awarded M R Kurup Gold medal for Young Scientist for the excellent contributions in the area of Radiography of Solid Propellant and Space ordnance system.

Chief Radiological Safety Officer of Vikram Sarabhai Space Centre (VSSC), ISRO

32 papers are published in Seminar/Conferences.

Life member in Indian Society for NON-Destructive Testing (ISNT), Aeronautical Society of India(AeSI), High Energy Materials Society of India (HEMSI), Indian Society for Aerospace Related Mechanisms(INSARM), Society for Aerospace Mechanical engineering (SAME) and Society for Quality and Reliability (SQAR).





## Computed Tomography for NDE of Ordnance Systems in Indian space Programme

**IT 08** 

THE ABSTRACT

Gunasekaran R Head, Radiography and Inspection Division (RID) VSSC, ISRO

NDE plays an important role in the screening and acceptance of pyrotechnic devices and explosive system used in launch vehicle and satellite for flight critical operations. Detailed NDT investigations of pyros with 3D visualisation is essential towards ensuring fail proof functioning of pyro systems for human space missions. Being known that Computed Tomography (CT) is the only tool for NDE of components with 3D visualization, a CT facility is established with all mandatory safety features for inspection of explosive systems. This CT facility is equipped with a Dual energy (3.5/6MeV) Linear accelerator (LINAC), and a 450 kV X-ray machine to cover various types of pyro devices and systems.

This presentation highlights details on the design, issues faced during realisation and installation/integration of different subsystems such as manipulator, digital flat panel detector (DFPD), X-ray sources and reconstruction software. This method signifies a substantial advancement in Non-destructive testing, offering improved imaging capabilities and operational efficiencies in the NDE of pyro systems. Different Pyro devices and systems tested using the facility is also highlighted in the presentation



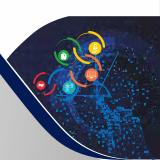




**Dr. Jyotirmayee Dash**Founder & CEO, TeraLumen Solutions

Dr. Jyotirmayee Dash is the founder and CEO of TeraLumen Solutions, a pioneering company specializing in Terahertz (THz) technology applications. Renowned for her expertise in THz science, Dr. Dash has driven innovative advancements in non-destructive testing (NDT), structural health monitoring, and process analytics using cutting-edge Terahertz technology. She earned her PhD from CSIR-Central Electronics Engineering Research Institute (CEERI) in Chennai, focusing on applications of Terahertz technology. Dr. Dash has made significant contributions to the field with three international patents and numerous publications in esteemed international journals and conference proceedings, where she has shared insights into leveraging THz technology for practical industry applications. With extensive expertise in the field of Terahertz applications, Dr. Dash has significantly contributed to the development and commercialization of THz-based systems for various healthcare and industrial applications.





## Terahertz Technology for Non-Destructive Testing and Real-Time Monitoring: Applications in Composites and Lithium-Ion Battery Electrode Coating

IT 09

THE ABSTRACT

Jyotirmayee Dash TeraLumen Solutions Pvt. Ltd.

Terahertz (THz) technology has established itself as an effective non-destructive testing (NDT) technique for the detection of substances and various structures. Effectiveness and accuracy of this technology have been extensively demonstrated in numerous applications including process analytical technology, quality control , non-destructive testing and structural health monitoring. This talk provides an insight of suitability of THz NDT in various real world application scenarios such composites defect detection and evaluation, coating thickness on Carbon fiber-reinforced polymers composites and paint and coating thickness measurement and characterization. This talk also emphasizes on use of Terahertz technology for coating thickness measurement of lithium-ion battery electrodes. An important challenge in lithium-ion battery production is to optimize the manufacturing process for electrode coatings (anode and cathode). THz device offers a solution that provide density and thickness measurement, allowing real time control monitoring.





## Srinivas Kuchipudi

Defence Research and Development Organisation (DRDO), Advanced Systems Laboratory (ASL), Hyderabad-500058, Telangana. India

**Present Employment** Scientist G, DRDO

> **Deputy Technology Director** Directorate of R & QA

Advanced Systems Laboratory,

Kanchabagh P.O.

Hyderabad -500058, INDIA Email: srinivas.asl@gov.in

A) Academic record

1) Doctor of Philosophy (Ph.D) in Physics Osmania University, Hyderabad, INDIA

2) RESEARCH EXPERIENCE: 24 Years in Material characterization and

non-destructive evaluation of composite structures.

Areas of work: Solid state NMR, Microwave NDE, Thermography,

**Ultrasonics** 

3) Award/ Honours,: 1) DRDO Technology Group award 2008

2) AGNI award for excellence in self reliance for

year 2011

3) DRDO Titanium medal for the year 2012

1) Research Guide for Ph.D and Masters students

Department of physics, Osmania University, Hyderabad

2) Research guide for Ph.D students

Department of Physics, JNTU, Ananthapur, India

5) Number of students Ph.D /Masters:

Guided

2 Phd Students pursuing their work

6) No of publications:

4) Academic recognitions

G) Membership of Professional

Societies/Institutions:

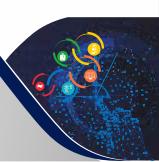
55 (International) 58 (national and conference papers)

Life Member, ISAMPE, L-719 Life Member, SAQR, L-172 Life Member, ISNT, LM-7938 HD Life Member, NMRS,L13-351

Fellow Optical society of India, 1143

Member, MRSI (AMB 267)





# Nondestructive Evaluation of High-Energy Materials and Interfaces Using Low-Frequency Proton NMR

**IT 10** 

THE ABSTRACT

Srinivas Kuchipudi<sup>1\*</sup>, Ajay K Singh<sup>1, 2</sup>, Veeresh Kumar GB<sup>2</sup>

<sup>1</sup> Defence Research and Development Organisation (DRDO),

Advanced Systems Laboratory (ASL), Hyderabad-500058, Telangana. India.

<sup>2</sup> Mechanical Engineering Department, National Institute of

Technology-Andhra Pradesh, Tadepalligudem-534101, Andhra Pradesh. India.

\*Email: Srinivask.asl@gov.in

Nondestructive evaluation (NDE) of high-energy materials containing a hydroxyl-terminated polybutadiene (HTPB) polymer elastomeric binder is of significant interest. While other NDE techniques, such as high-energy X-ray radiography and ultrasonics, are available, they are often ineffective at capturing microscopic changes in polymeric binder materials due to the inherent limitations of these methods. In this paper, we report on the nondestructive evaluation of high-energy materials with an HTPB binder, focusing on their properties related to cross-link density as measured by NMR relaxation times. We also attempt to correlate the NMR findings with the mechanical properties of HTPB. Additionally, this study investigates the adhesive bond between high-energy materials and the insulation layer using low-frequency NMR, with measurements taken in 100-micron steps to assess bond integrity and interfacial properties. Results from the study of HTPB-based high-energy material bonded with an elastomeric insulation liner using single-sided, low-frequency proton NMR are presented. A detailed investigation revealed that the adhesively bonded interface exhibits a higher proton density compared to the adherent and substrate.

Keywords: NMR, Elastomer, Adhesive Binder, Interface Properties







## Dr. Digendranath Swain

Scientist/Engineer SF,
Section Head, Experimental Techniques Section (ETS)
Experimental Mechanics Division (EXMD),
Vikram Sarabhai Space Center, ISRO PO, Trivandrum

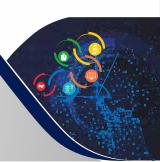
Dr. Digendranath Swain obtained his doctoral degree from IIT Kanpur, specializing in Solid Mechanics and Design. He has been working as a scientist at Vikram Sarabhai Space Center (VSSC), ISRO, for the past 18 years. Dr. Swain is heading the Experimental Techniques Section (ETS) of the Experimental Mechanics Division (EXMD) of VSSC. His current research areas include digital image correlation (DIC), digital photoelasticity, residual stress measurement, digital shearography, solid mechanics, and biomechanics.

He has authored and co-authored 24 journal papers, five book chapters, and 35 conference papers. He has three granted patents to his name. He has been an active reviewer for 15 international journals and is recognized as an outstanding reviewer by some journals. He serves as an editorial board member in the Journal of Non-Destructive Testing and Evaluation (JNDE), published by the Indian Society for Non-destructive Testing (ISNT). He was a guest editor for a recent specialissue on "Optical Non-destructive Evaluation (ONDE)," which was a first of its kind in JNDE.

Dr. Swain'steam has participated in all the innovation contests held at VSSC and was shortlisted thrice as the top performer. He has received the ISRO Young Scientist Merit Award in 2014. He was also conferred with the ISNT National NDT Award for NDT systems innovation and development in 2022. Just a few months ago, he was bestowed with the most prestigious "Rashtriya Vigyan Puraskar: Vigyan Yuva- Shanti Swarup Bhatnagar award" by the president of India.

He is an avid supporter of science outreach to the general public. Towards this, he took the initiative to conduct World Space Week 2024 for the first time at the rural and remote schools and colleges in Odisha to educate the budding young brains about the inspiring Indian space saga.





# The emergence of India Make Portable and Real-time Shearography System (IMPRESS)

IT 11

THE ABSTRACT

Dr. Digendranath Swain, Scientist/Engineer SF, Section Head, Experimental Techniques Section (ETS) Experimental Mechanics Division (EXMD), Vikram Sarabhai Space Center, ISRO PO, Trivandrum

Over the years, optical NDE (ONDE) methods haveplayed a significant rolein the automotive, aerospace, power, and manufacturing industries for locating and sizing defects/flaws in a component with full-field capability. Depending on their operating principle, such NDE methods can be classified as interferometry or non-interferometry-based techniques. Similarly, considering the output/results of these techniques, they can be grouped under qualitative or quantitative optical NDT methods. This presentation will discuss an interferometric-based ONDE technique known as laser speckle shearing interferometry, aka shear ography, which is mostly qualitative for most NDE applications. This talk will deliberate on the history and evolution of the in-house developed shear ography system in VSSC, namely the "India Make Portable and Real-time Shear ography System (IMPRESS)." The presentation will begin with the basic concepts of optical interferometry and will dwell on the fundamental understanding of shear ography. The talk will also cover the motivation behind developing IMPRESS, the technical know-how, and the results obtained with version1 of the system. Subsequently, the development of version2 of the inhouse system will be dealt with, wherein the importance of phase map generation in shear ography will be presented. The improvements obtained in version 2 of IMPRESS are demonstrated before concluding the talk.







Anthony Croxford
University of Bristol, Queens Building, Bristol, BS8 1TR UK

Anthony Croxford is Professor of Ultrasonics and Dynamics at the University of Bristol and has published over 60 refereed journal papers, over 80 conference papers and has 7 granted patents. His expertise is in the use of sensor arrays for defect detection and characterisation, structural health monitoring, nonlinear ultrasonics and the application of data science and machine learning to NDE. He is Programme Director for the Future Innovation in NDE Centre for Doctoral Training (FIND CDT) Career highlights include: over 10 EPSRC and InnovateUK grants; Prestigious UK government EPSRC Research Fellowship (2015-20); Turing Fellow (2021-22) editorial board member for Ultrasonics and Journal of NDE. He is also director and cofounder (2015) of spin-out company Inductosense Ltd. that is commercialising permanently-installed, inductively-coupled ultrasonic sensors





## Data Based Techniques to Enhance Phased Array Performance

**IT 12** 

THE ABSTRACT

Anthony Croxford<sup>1</sup>, Paul Wilcox<sup>1</sup> and Matthew Chandler<sup>1</sup>
<sup>1</sup>University of Bristol, Queens Building, Bristol, BS8 1TR UK. a.j.croxford@bristol.ac.uk

Ultrasonic passed arrays have had a dramatic impact on the performance of inspections. The large quantities of data present in FMC provides much information about the ultrasonic scene. This paper will explore how the data present in such an acquisition process may be used to enhance the performance of ultrasonic inspections. We will explore this in two main ways, firstly how data from multiple echoes may be used to produce multiple images from a single dataset. With understanding of the underlying physics appropriate detection approaches can be derived and data fused. We will show how this improves detection performance significantly, with an exploration of the ability to detect and characterise features. The difference between between small and large defect features will also be touched upon. The second approach will address how data may be used to address that problem of imaging in the presence of artefacts. Here, multiple defect free datasets will be used to characterise the underlying statistical distribution and design an appropriate detector. This will then be used to show how images with high signal to noise performance may be formed in areas that do not have line of sight. Here the use of multiple views has a significant impact on the overall performance. This will be extended to the problem of areas based detection, specifically focussed on the detection of waviness in composite samples. Together these approaches demonstrate how statistical modelling and data can improve both the performance and capabilities of phased array inspections, allowing effective inspection of a wider range of materials and geometries.

Keywords: Ultrasonic, phased array, data fusion.





**Christian Els**Sentin GmbH Germany

Christian Els is one of the co-founders and CEO of sentin GmbH. His company offers Al and digital automation solutions for Non-Destructive Testing and Inspection in a wide range of industries. Prior to sentin, Christian worked at Bosch, implementing digital services and products into the company's traditional business lines. He is chairman of the Al work group of the German Society for Non-Destructive Testing, Chairman of the DIN technical committee on Al in NDT, Member of the ASNT standardization committee for Al/ML in NDT and member of the standardization work group on Al/ML of ASNT. Also he is regular speaker at various international conferences on Al in NDT, digital transformation and entrepreneurship.





# A practical concept for using AI in NDE applications - Introducing CID (Critical Image Detection) and SIDA (Single Image Detail Analysis)

**IT 13** 

THE ABSTRACT

Christian Els, Maximilian Topp, Dominik Nestler sentin GmbH Germany | Suedring 25 | 44787 Bochum, Germany | www.sentin.ai Phone: +49 234 54506170 | Contact e-mail: contact@sentin.ai

As Artificial Intelligence (AI) reshapes Non-Destructive Testing (NDT) and Evaluation (NDE), new methods are emerging that extend beyond traditional Automated Defect Recognition (ADR). This paper introduces Critical Image Detection (CID) and Single Image Detail Analysis (SIDA), two pioneering approaches designed to enhance inspection accuracy by prioritizing critical images and applying tailored, multialgorithm analyses. We explore the digital infrastructure needed to implement these advancements, drawing on case studies from the energy industry, with a particular focus on oil and gas. Applications include AI-driven detection of critical images in radiographic testing of castings in the energy sector. Further examples from oil and gas highlight the use of CID and SIDA in inspection verification, auditing, and fraud detection. These case studies demonstrate the practical benefits of CID and SIDA, underscoring AI's potential to optimize NDT/NDE processes across energy applications.

**Keywords:** Artificial Intelligence, Critical Image Detection, Single Image Detail Analysis, NDE 4.0, NDT 4.0, AI, Energy Industry







## Paresh Haribhakti Managing Director, TCR Advanced Engineering Services

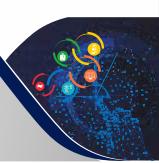
Paresh Haribhakti, Managing Director of TCR Advanced Engineering Services, is a trailblazer in in-situ metallography and a distinguished failure investigation expert, with a record of over 8,000 industrial cases resolved across refinery, petrochemical, power, and chemical sectors.

With advanced training in Materials Technology from M.S. University, Paresh has made significant contributions to leading metallurgical journals and shared his insights at global conferences. A passionate advocate for knowledge sharing, he established 'TCR Evolve,' a training academy dedicated to fostering expertise among engineers and professionals.

Paresh has authored the definitive guide, Failure Investigation of Boiler Tubes, and contributed to ASM's Handbook, Volume 11A. His dedication extends beyond publications to pioneering practical solutions: he developed AiOM™, an Asset Integrity Management tool that advances reliability and safety in industrial operations.

Under his leadership, TCR Advanced Engineering is committed to tackling complex metallurgical challenges, delivering impactful solutions, and advancing industry standards worldwide





#### What, When, and How to Inspect: Unlocking the Secrets to Effective Asset Integrity.

IT 14

THE ABSTRACT

Paresh Haribhakti MD TCR Advanced paresh@tcradvanced.com

In the highly demanding environments of the refinery, petrochemical, fertilizer, chemical, and power industries, asset integrity is critical to ensuring the safety, efficiency, and longevity of critical infrastructure. One of the greatest challenges these industries face is understanding and managing the complex damage mechanisms that affect equipment such as pressure vessels, pipelines, heat exchangers, and reactors. These mechanisms—ranging from corrosion and erosion to fatigue, stress corrosion cracking, and creep—are influenced by factors like temperature, pressure, chemical exposure, and mechanical stresses, materials of construction, fabrication and welding.

A comprehensive understanding of metallurgy and corrosion with overall engineering aspect is essential for predicting the onset of these failures and damage mechanisms. Metallurgical knowledge informs material selection to resist harsh operating conditions, while corrosion expertise guides the design and implementation of effective prevention and mitigation strategies. Even with these fundamental insights, early detection and monitoring of damage mechanisms remain essential for effective plant life extension. Success in an NDT program and asset integrity relies on having precise knowledge of what to inspect, when to inspect, and how to inspect.

This presentation will explore key damage mechanisms such as HTHA, HIC, Creep, SCC and high temperature material degradation, in the context of the petrochemical, refinery, fertilizer, chemical, and power industries, highlighting how NDT techniques can be employed to detect, assess, and mitigate these threats. Case studies will demonstrate the power of combining metallurgical knowledge with advanced NDT methods to optimize asset integrity management and ensure reliable operation. By incorporating NDT expertise into routine inspection programs, industries can proactively prevent failures, reduce maintenance costs, and extend the life of critical assets.

The session will also emphasize the importance of NDT professionals' expertise, data base management and in interpreting complex data and making informed decisions based on their findings, thereby reinforcing the role of NDT as an indispensable element in the overall asset management strategy.

**Keywords:** Damage mechanisms, metallurgy, corrosion, asset integrity, Non-Destructive Testing (NDT), failure prevention, refinery, petrochemical, chemical, power industries, inspection technologies, asset life extension.







Balaji Srinivasan

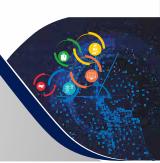
Department of Electrical Engineering, IIT Madras

Balaji Srinivasan obtained his Ph.D. in 2000 from the University of New Mexico, USA. He subsequently worked as a Senior Development Scientist at Corning Incorporated, USA, where he led technology development efforts related to 3D Optical Cross-connects and Channel Selectable Tunable Filters. Since 2004 he has been with the Indian Institute of Technology Madras as a faculty in the Department of Electrical Engineering, presently as Professor.

Balaji's research interests span the development of active and passive optical components / subsystems for distributed fiber optic sensors and fiber lasers. Balaji has co-authored more than 230 journal and international conference publications, as well as 4 book chapters. He also has 23 patents to his credit (3 more pending). He has successfully executed or currently investigating over 40 research projects, resulting in the development of 8 technologies, 6 of which have been transferred to industry for commercialization.

Balajihas served in the Editorial Board of the prestigious Optics Express journal, andis one of the Directors of Folium Sensing Pvt Ltd, a distributed fiber sensor company incubated by IIT Madras. He has previously served as Member of the Photonics Working Group of the Department of Electronics and Information Technology (DEITy), Government of India, Steering Committee of the National Photonics Fellowship, the Editorial Board of the Springer Photonic Network Communications Journal, and as a Chair for the 2012 International Conference on Fiber Optics and Photonics. For his professional accomplishments, he has been awarded Senior Membership in Optica.





## Opportunities for Distributed Fiber Sensors for 3P in Industrial Environments

**IT 15** 

THE ABSTRACT

Balaji Srinivasan Department of Electrical Engineering, IIT Madras balajis@ee.iitm.ac.in

In the present day industry scenario, it is imperative that the 3Ps i.e., Process Control, Product Quality Assurance, and Predictive Maintenance are implemented on a real-time basis and also in a distributed manner across the industrial process lines. Distributed optical fiber sensors based on scattering of light in optical fibers provide a tremendous opportunity to carry out such 3P activities since they are capable of accurately measuring physical parameters such as strain, temperature, vibrations, and even acoustics over distances ranging from a few tens of meters to tens of kilometers. In this talk, we will highlight such capabilities of distributed optical fiber sensors with specific case studies relevant to the industrial environments.







**Dr. Ernst Niederleithinger**BAM-Germany

- 1990-2001 deputy head in an engineering firm (geophysics)
- Since 2001 BundesanstaltfürMaterialforschung und –prüfung (BAM), now head of division 8.2 "NDT methods for civil engineering"
- Since 2012 Lecturer (Privatdozent) at RWTH Aachen University
- Guest Researcher/Professor in USA, Australia, Slovenia, Finland and Scotland
- Associate Editor of "Journal of Non-Destructive Evaluation" (Springer Nature)
- (Co-)Organizer of various workshops and conferences (e. g. NDT-CE Symposium 2015, 2018, 2022, EWSHM 2024)
- (Co-)Author of NDT and monitoring guidelines and standards (DGZfP, ASTM, DIN)





### Paths towards digitalization in NDT for civil engineering

IT 16

THE ABSTRACT

PD Dr. rer. nat. Ernst Niederleithinger Bundesanstalt für Materialforschung und prüfung, Berlin, Germany

The construction industry is one of the most important sectors of the global economy. It makes a significant contribution to gross national product and overall employment. More importantly, it provides many of the basic needs of society (e.g. housing, infrastructure, protection from natural hazards). The concept of 'Industry 4.0' or 'smart production' has not yet made significant progress in the construction industry. In fact, civil engineering is one of the industries with the lowest level of digitalisation and productivity gains. But this is changing. Over the past decade, several drivers have challenged the way clients, contractors and authorities currently operate. These drivers include, but are not limited to, the increasing demand for serialisation and automation, or the mandatory introduction of Building Information Modelling (BIM) in public procurement, as well as the forthcoming use of digital twins. NDE is playing an increasing role in auality assurance, condition assessment and monitoring of structures. However, with very few exceptions, applications are mostly non-standardised and only performed at selected sites. To change this, the NDT-CE community, including manufacturers, service providers, clients and academia, needs to work consistently on open data formats, interfaces to BIM, standardisation and validated ways to use the results quantitatively in the assessment of structures. In addition, NDE 4.0 could also help address other challenges in the construction industry: the need to reduce the impact of construction on climate change, the lack of skilled labour in many countries, and the generally limited resources available.







#### Saptarshi Sasmal

Chief Scientist & Head Special and Multi-functional Structures Laboratory Professor, Academy of Scientific and Innovative Research CSIR-Structural Engineering Research Centre CSIR Campus, Taramani, Chennai 600 113

#### Research interest:

Nonlinear ultrasonics/acoustics, multi-metric structural health monitoring (SHM) and life extension, Smart/multifunctional composites, nano/micro scale engineering, computational mechanics and multi-scale modelling

#### **Academic Qualifications:**

- 1. B. E. in Civil Engineering (First Class with Honours), Jadavpur University, West Bengal, 1998
- 2. M.E. in Civil Engineering (Department Topper and Gold Medalist), Jadavpur University, West Bengal, 2000
- 3. Ph. D in Civil Engineering, University of Stuttgart, Germany, 2009 (Thesis title: Performance evaluation and strengthening of deficient beam-column sub-assemblages under cyclic loading) with Outstanding Grade

#### **Publications:**

SCI/Peer-reviewed Journals (published): 142
Journals (revision/review): 10
Conference Publications: 103
Book/book chapters: 13
Technical Reports (in-house and sponsored R&D): 74

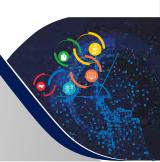
M.E./M.Tech. Research Guidance: 21 (Completed)

Ph.D. Guidance: 04 (Completed) + 03 (on-going)

#### **Editorial responsibilities for Journals:**

- Associate Editor: ASME Journal for Non-destructive Evaluation
- Associate Editor: Transaction of Transactions of the Indian National Academy of Engineering (INAE)
- Editor: Journal of Structural Engineering
- √ Editorial Board Member Structural Engineering and Mechanics
- Editorial Board Member -Advances in Computational Design





## Nonlinear Ultrasonics- A Powerful NDE Tool for Early-Stage Damage Detection in Concrete

Saptarshi Sasmal<sup>1,2</sup>

1,2 Structural Engineering, Academy of Scientific and Innovative Research, Ghaziabad, India

<sup>1,2</sup> Special and Multi-functional Structures Laboratory (SMSL), CSIR-Structural Engineering Research Centre, Chennai, INDIA

Email: saptarshi@serc.res.in, sasmalsap@gmail.com

THE ABSTRACT

IT 17

Structural Health Monitoring is an emerging technique which performs diagnosis and prognosis of structural health condition by combining advanced sensor technology with intelligent algorithms. From the aspect of total investment and preservation of constructional heritage, the non-destructive evaluation (NDE) techniques gained attention over past few decades in academia and industries. Eddy current, liquid penetrant, radiography, acoustic emission, ultrasonic testing are some of the well-known techniques, which come under non-destructive evaluation (NDE). Ultrasonic methods are the most active field of research in NDE because it has a great potential to detect very small sized damages (barely visible) caused by several factors like, fatigue, corrosion, porosity, creep, static/cyclic loading and unloading.

From past few decades, ultrasonic wave propagation methods (specially nonlinear ultrasonic methods-NLU) are found to be very promising in detecting wide range of damages. As, the pulses are of higher frequency (low wavelength), they can interact several times with the microcracks within the structure and bring out the maximum signature of the damage induced nonlinearities. While interaction, the incident wave undergoes reflection, refraction, wave modulation, attenuation, phase transformation, wave diffusion, scattering and so on. Researchers perform several linear and nonlinear ultrasonic methods, such as, pulse velocity, attenuation, wavelet packet decomposition, Hilbert phase, diffusion, coda wave interferometry, nonlinear attenuation, scaling subtraction method, higher harmonic methods, sideband peak count, sideband energy ratio, energy based nonlinear acoustic parameter, pattern recognition methods to detect damage characteristics and the stress changes within the structure. This invited talk mainly focuses on three critical and unique aspects, 1) in depth microstructural study to address the wavematter interaction phenomenon, 2) critical damage condition monitoring and stress state evaluation in concrete structures that can help to carry out structural health monitoring for in-situ structures, and 3) the need of improvisation of existing ultrasonic methods, as well as, the establishment of advanced nonlinear ultrasonic methods to successfully monitor various critical damages and stress scenario.

**Keywords:** Nonlinear ultrasonics; Wave-matter interaction; Stress-induced damage; Interface flaw detection; Corrosion damage.





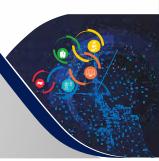


V.H.Patankar

Bhabha Atomic Research Centre (BARC)

Dr. V.H.Patankar graduated in Electronics from Shivaji University, joinedBARC in 1988 and acquired doctorate from Mumbai University, in 2007. More than 30 years, he is engaged in the design and development of an automated ultrasonic imaging systems for NDT of nuclear reactors. He is a Professor & PhD Guide at Homi Bhabha National Institute (HBNI), Deemed to be University of Dept. of Atomic Energy andfourscholars have completed PhD under his guidance. He has more than 80 Peer-reviewed journal papers in his credit and has receivedISNT National NDT Award 2003 at Thiruvananthapuram. He belongs to Sangli and loves music & travelling.





# Ultrasonic Instrumentation for NDE of Components&Structures and Way Forward

IT 18

THE ABSTRACT

#### V.H.Patankar

Electronics Division, Bhabha Atomic Research Centre (BARC), Mumbai-400085 and

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Ultrasonic Testing (UT) has become very much powerful Non-Destructive Evaluation (NDE) technique and tool for the inspection,imagingand life-assessment of metallic components such as billets, rods, plates, tubes/pipes, machined intricate components, cladded plates, nozzles, welded joints etc. and non-metallic components such as refractory blocks, CFRP/GFRP/honeycomb structures, Concrete/RCC types of civil engineering structures, HDPE/LDPE pipes etc.

UT method is employed during Pre-fabrication, In-Service-Inspection (ISI) and Post-Service-Inspection (PSI) stages of the plants, equipments, structures and large vital installations of Nuclear Power Plants, Defense, Aerospace/Aviation/Aeronautics, Marine/Offshore/Underwater, Oil & Gas/Petrochemical,Road/Rail Transportation and Civil Engineering Construction, Manufacturing and Infrastructure industries.

The UT technique has been evolved over decades, right from the basic testing, based-on the single-transducer based routinely employed Pulse-Echo contact scanning type systems to the latest Total Focusing Method (TFM) and matrix-based Phased Array Ultrasonic Testing (PAUT) systems for beam forming and beam focusing requirements of ultrasound. Pulse-Echo& Immersion types of UT, Air-coupled ultrasonics, Non-linear ultrasonics, EMAT and SAM are the major types of UT instrumentation systems which are utilised for various industrial applications.

Electronics Division, BARC, Mumbai has a long legacy of over four decades, in the design-development-deployment of computer/ FPGA-based automated ultrasonic imaging systems suitable for the inspection, gaugingand imaging of mechanical components and structures of Pressurized Heavy Water Reactors (PHWR), Boiling Water Reactors (BWR), Prototype Fast Breeder Reactor (PFBR), Light Water Reactor (LWR) types of nuclear power plants. Further to these activities of ED, BARC, there is a need to augment these sophisticated types of ultrasonic instrumentation systems for the NDE of modern components and structures of various industries, with following features and these aspects will be discussed.

- Very high-speed inspection
- Highly-sensitive, focused and high-temperature ultrasonic transducers
- 14-16 bits High-speed Digitization for 1-D data and 2-D images and FPGA-based Data Acquisition
- Compact and low power instrument with high-speed computation and large data/image storage
- WiFi/Bluetooth/USB/Ethernet/Wireless connectivity and GPS for Data Acquisition
- Ease of automation-interface using multi-axes mechanical scanner/crawler/ROV/drone
- Built-in Artificial Intelligence(AI) for accurate detection-sizing-characterisation of defects
- Web-based/Satellite communication-based, On-line system operation/diagnostics of instruments
- Field employable and battery-operated systems, havingShort down-time for systems
- Environmental-EMI/EMC-Shock/Vibrations compliances
- Ease of customization for system software and data/image analysis modules
- Long life-spanforthe instrumentation system design and spares







#### **Pranay Wadyalkar**

OMS Software Australia, 19 The Strand Williamstown Melbourne, Australia

Pranay Wadyalkar is a Chartered Engineer, CMatP, Metallurgist, AICIP, AINDT L3 in ET, UT, RT, MT, PT. Currently, as the MD at OMS Software, a digital automation company providing advanced LIMS & business management platform for Labs. Prior to OMS, he founded LMATS, the largest privately owned Australian business in the field of metallurgy, mechanical & chemical testing, NDT, Inspections. Pranay is appointed on the NATA's NDT Advisory Committee, Steel Association Board, Australian delegate on the ICNDT, APFNDT & NDE4.0SIG. Pranay was the AINDT President from 2014-2016, and a director (2009-2017).

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#### NDE N\_Ext for Future Labs

IT 19

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Although the TICS industry has been advancing by leaps and bounds, the term "NDE 4.0" isbuzzing in the past few years. While some are already calling "Industry 5.0", NDE industry is still struggling to adopt the 4.0. One reason could be that many IT / instrument providers are focusing solely on NDE rather than a comprehensive solution for the entire ecosystem.

The ecosystem includes the entire organisation, laboratory, staff, and several interconnected bodies (accreditation, regulatory, taxation), customers, suppliers. Moreover, the laboratory may also be conducting Metallurgy, mechanical & chemical testing or allied processes (survey, heat treatment, inspection). Hence, the current 4.0 model, focused on just NDE, is less favorable for our industry to satisfy the entire ecosystem.

As the sole founder owner of the largest privately owned Australian laboratory business, the author has faced many challenges while implementing digitalisation. Our industry can be inefficient by using several fragmented generic Apps developed by major OEM or individual providers. The author wishes to share insights about genuine requirements of the TICS industry. We must think beyond NDE 4.0 and adopt a factual eco-system "NDE N\_Ext",, based on the overall NDE & extended services.

The term "NDE N\_Ext" is an indicator of actual NDE innovations over the past decades& future developments. The term "N\_Ext" allows us to go beyond industry 4.0 or 5.0, and comprises extension to several interconnected testing fields, business compliance processes, and also other entities interacting with a laboratory in the eco-system.

"NDE N\_ Ext" covers comprehensive objectives and ever evolving goals for NDE & beyond. The author will share an IT architecture about true "NDE and extension" wherein the entire eco-system is cyber-human-cyber model, or possible to link with other industry 4.0 (& beyond) entities. A success story about the true eco-system, that is being used by many Australian labs since 2014. It will indicate gross savings achieved by digital automation that is cyber communicating with other entities or can connect with other cyber ready entities.

Keywords: NDE, TICS, Laboratory, Digital automation, Cyber communication, IT.







**Dr. Shruti Bharadwaj**Scientist C, Indian Institute of Technology Delhi, India

Dr. Shruti Bharadwaj received her Ph.D. degree from Rajiv Gandhi Institute of Petroleum Technology Uttar Pradesh, India in the field of Geospatial 3D mapping for Noise Prediction. Presently, she is serving as a Scientist C in Indian Institute of Technology Delhi, India. Herresearch interests include the development of Al/ML for infrared imaging for bio-medical/industrial imaging.





# Title of the talk:Thermography as a Diagnostic Tool: Exploring Its Applications in Healthcare

**IT 20** 

THE ABSTRACT

Dr. Shruti Bharadwaj Scientist C, Indian Institute of Technology Delhi, India

Thermography is a non-invasive imaging technique that captures infrared radiation to map temperature variations over the body. It is widely used in medical diagnostics to detect physiological changes such as inflammation, vascular abnormalities, and tumors. This safe, portable, patient friendly and cost-effective imaging approach is particularly valuable for early disease detection at large-scale screening. This talk highlights the capabilities of infrared imaging in context of oral cancer byidentifying the abnormal thermal patterns associated with metabolic and vascular changes in oral tissues. Analysis of thermographic data from the clinical studies and thereby considering the texture analysis, mean temperature evaluation, and temporal trends and their relative variations in distinguishing the normal, inflammatory, pre-cancerous, and cancerous conditions. Further emphasis will be given to the role of Al/ML for automatic detection and classification of the stage of oral cancer.



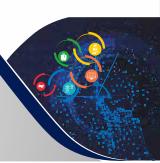




**Dr. Vanita Arora**Technical Specialist (Vision Systems),
SS Automation Solutions Pvt. Ltd.,
Bengaluru, India

Dr. Vanita Arora received her Ph.D. degree from Indian Instituteof Technology Ropar (IIT Ropar), India in the field of infrared imaging. Presently, she is serving as a Technical Specialist (Vision Systems) at SS Automation Solutions Pvt. Ltd., Bengaluru, India. Herresearch interests include the development of infrared imaging systems fornon-invasive/non-destructive testing applications. She serves as an Editor/Guest Editorfor several refereed journals of IEEE, IET, IOP etc.





## Advances in Infrared Vision Systems for Thermal Non-destructive Testing and Evaluation Applications

**IT 21** 

THE ABSTRACT

Dr. Vanita Arora Technical Specialist (Vision Systems), SS Automation Solutions Pvt. Ltd., Bengaluru, India

InfraRed Thermography (IRT) is one of the promising whole field imaging modalities for non-destructive testing and evaluation of a wide variety of materials. IRT gained wide acceptance due to its inherent merits such as safe, remote, fast, and easy to deploy in the field, for testing and evaluation of various materials irrespective of their electrical and magnetic properties. Among the widely used IRT approaches, recently introduced pulse compression favorable excitation schemes have gained their popularity due to their improved test sensitivity and resolution even with the usage of low peak power probing energy into the test material. This talk highlights various infrared imaging systems available in practice and adopted signal and video processing approaches for enhance the test sensitivity and resolution. Further the merits and limitations of these systems and data processing approaches will be discussed for subsurface feature visualization in various industrial materials.







#### Sanjay Kumar Rai

Scientific Officer/H, Head, X-ray Diffraction and Metrology Section, Accelerator Physics and Synchrotrons Utilization Division, Raja Ramanna Centre for Advanced Technology E-mail: sanjayrai@cat.ernet.in

Personal Details: Born on 29th June 1969

#### **Educational Qualifications:**

1990 M.Sc. (Physics) from Indian Institute of Technology Delhi, New Delhi, India.

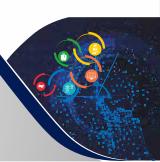
2013 PhD from HBNI in Development of thin film based X-ray Optics

#### **Experience**

- a. 34 years of experience in x-ray diffraction and its application in stress measurement, thin film characterization,x-ray reflectivity and powder diffraction.
- b. Indigenous development of Hard-x-ray reflectometer/diffractometer on a x-ray tube source.
- c. Development of thin film based x-ray mirrors and optics for synchrotron sources.
- d. development of a new diffraction based beamline for doing stress measurement of actua components and for in-situ characterization of thin films
- e. Worked on various projects of national importance such as Assessment of in-servicein the landing gears of fighter aircrafts as part of their life extension programme undertaken by Indian Air Force (IAF). This project helped in optimum utilization of the landing gears and taking decision on extending their life with high reliability and without jeopardizing the safety of the aircraft.
- f. He contributed or development first Indian x-ray telescope ASTROSAT developed jointly by TIFR and DRDO.

More than 200 Papers in International journals and conferences





# Synchrotron radiation an emerging tool for non-destructive assessment of stress and micro-structure in engineering components

**IT 22** 

THE ABSTRACT

Dr. Sanjay Kumar Rai X-radiffraction and Metrology Section Raja Ramanna Centre for Advanced Technology, Indore.

In order to predict the durability of engineering components and improve the performance, it is mandatory to understand the structure of material used for fabrication and its influence on the physical property. Presence of residual stresses and unfavourable texture can significantly affect the performance of components. Residual stresses can reduce fatigue life, enhance stress corrosion cracking, and enhance creep deformation rate. Stresses get generated in almost in every process used for fabrication of components like milling, cutting, welding, grinding, depositing, rolling etc.

Successful management of residual stresses is very critical for getting optimum performance.X-ray diffraction based methods are excellent tools for non destructive estimation of stress and texture in materials. Synchrotrons provide an intense, collimated and tunable x-ray beam for stress analysis. This makes it ideal for carrying out stress measurement with high spatial resolution also tunability provides possibility of doing depth resolved stress measurements. This talk will show examples of synchrotron based stress measurements in welds, rolled joints and thin film coatings. We will also present how synchrotrons have been used for carrying out stress measurements on the inside surface of a tube. How in future synchrotrons can be useful in solving engineering problems non-destructively will be discussed.





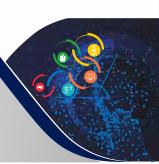


Dr. Sauvik Banerjee

Professor
Department of Civil Engineering
Indian Institute of Technology Bombay, Powai, Mumbai 400076

Dr. Sauvik Banerjee is currently a Professor of Structural Engineering in the Department of Civil Engineering, Indian Institute of Technology (IIT) Bombay. Prior to joining IIT Bombay in the year 2008, he had spent three years as an assistant professor at the Parks College of Engineering, Aviation and Technology, Saint Louis University, USA. Dr. Banerjee's work focuses in the areas of structural health monitoring using wave propagation and vibration based approaches, ultrasonic nondestructive evaluation of structures, and dynamic modelling of advanced composite structures. He has published 170 international journal articles and conference proceedings, 1 book, 8 book chapters, and delivered invited talks in several important meetings in these areas. He has served as the Principal Investigator for several sponsored research and impactful industrial consultancy projects. He has supervised 20 doctoral students and 30 masters students, and several of them have won awards for their research contributions in a variety of forums. Dr Banerjee received Prof. S. P. Sukhatme Award for Excellence in Teaching at IIT Bombay in 2019 and Institute Excellence in Teaching Award in 2013. He is currently on the editorial boards the Journal of Nondestructive Testing and Evaluation, Taylor and Francis, and served as an associate editor of the ASME Journal of Nondestructive Evaluation, Diagnostics and Prognostics of Engineering Systems for 6 years.





#### Condition Assessment of Reinforced Concrete Structures Using NDT: Field Experiences and Laboratory Studies

**IT 23** 

THE ABSTRACT

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The first part of the talk will primarily involve a few case studies on understanding construction deficiencies and corrosion deterioration through NDT in Reinforced concrete structurers, and subsequently suggesting repairs and strengthening measures. In the second half of my talk, I will highlight ongoing research efforts on structural nondestructive evaluation and health monitoring utilizing ultrasonics and acoustic emission (AE) to solve some of the issues that arise from field experiences. This will include (a) continuous monitoring of corrosion in RC structures using ultrasonic guided waves for life cycle assessment (b) debond imaging in FRP strengthened concrete structures using ultrasonic surface guided waves (c) passive acoustic emission monitoring of emerging defects in RC structures (d) evaluation of bond deterioration between FRP bar and concrete in FRP reinforced structures.







#### **Anandmurugan Subramaniam**

Waygate Technologies, Baker Hughes, Bengaluru, India

Anandamurugan is India Engineering Leader for UT & global Product Management Lead for Ultrasound Software. Started his career as mechanical design engineer and then moved to NDT after completing his masters in NDT. He is having 18 years of experience in UT at Waygate Technologies. His area of interest is in Phased Array ultrasonic testing, TOFD, imaging and software development. He played a key role in development of advanced ultrasonic testing devices like Phasor XS; Mentor UT; comPAct and USM 100. He holds 5 patent and several publications. He is currently working on the software technologies for UT devices; AI-ML based technologies for UT Devices and Image Analysis.





#### The Role of Artificial Intelligence in Enhancing Repeatability and Detectability in Ultrasonic Testing: A Comprehensive UT Inspection Journey with AI

**IT 24** 

THE ABSTRACT

Anandamurugan S<sup>1</sup>, Gregor Wolf<sup>2</sup>

<sup>1</sup>Waygate Technologies, Baker Hughes, Bengaluru, India

<sup>2</sup>Waygate Technologies, Baker Hughes, Hürth, Germany

<sup>3</sup>Institution C, Address, Country

anandamuruga.s@bakerhughes.com, gregor.wolf@bakerhughe.com

Artificial Intelligence (AI) is transforming Non-Destructive Evaluation (NDE) by enhancing the repeatability and detectability of ultrasonic testing (UT), a critical NDT method to perform inspection of various applications. This paper explores the potential of how Alis used to optimize the complete UT inspection process, highlighting AI's role across various stages in the inspection workflowfrom Planning; Device Setup and Calibration; Inspection and Analysis of Results; Reporting of results; follow-up and recertification. This paper discusses in detail as how AI is suitable for Ultrasonic Testing at each stages mentioned above and the level of complexity in implementing AI based solution at each stage of UT inspectionworkflow.

Planning and Preparation: Al algorithms facilitate risk-based planning by analyzing historical data to develop inspection procedure and improving inspection efficacy.

Equipment Setup and Calibration: Al-basedcalibration algorithms help ensure standardized setup procedures, improving the consistency and repeatability of UT results.

Inspection and Analysis of Results: Machine learning models analyze UT images signals to detect patterns indicative of flaws in a specific application. These models improve detectability, identifying subtle anomalies that can assist inspectors may in increasing detection reliability.

Reporting of Results: Al-based reporting systems can generate standardized inspection reports by automatically compiling and analyzing data, and facilitating the traceability of UT results.

Storage of Data and Records: Data management frameworks categorize and store large volumes of UT data systematically, supporting long-term analysis and trend recognition using AI based algorithms.

Inspection Follow-Up and Recertification: Al supports ongoing inspection needs by comparing current inspection data with historical records to recommend the re-inspection, and corrective actions to be done and annual certification planning.

**Keywords:** Artificial Intelligence, Ultrasonic Testing, Non-Destructive Evaluation, Repeatability, Detectability, Inspection Workflow.







#### Dr. Balamurugan Srinivasagan

Head, Non-Destructive Testing & Sensors Research Group, R&D, Tata Steel Ltd., Jamshedpur

Mr Balamurugan Srinivasagan, is heading Non-Destructive Testing and Sensors Research Group in R&D, Tata Steel Ltd, Jamshedpur, who has been working in the area of non-destructive evaluation for the last 20 years. His areas of research interests include Non-destructive evaluation in process control, product quality assurance and predictive maintenance for steel industries. He joined in Tata Steel R&D in 2009.

He did his undergraduate in B.E., - Mechanical from Thiagarajar College of Engineering, Madurai in 2002 and then he completed his graduation in Non-Destructive Testing from NIT, Tiruchirappalli in 2004.

His experience includes five years as a lead engineer in ALSTOM for condition assessment of critical components in various power plants.

He was the recipient of "National NDT award for excellence in Industrial Applications in 2018" from Indian Society for Non-Destructive Testing (ISNT). Also, he was consistently recognised by "TATA INNOVISTA" a major event for recognition of innovations in the companies across the TATA group, where he won two awards in 2022", and a Regional Award in 2015.

He has published more than 15 technical papers in national and international journals /conferences, filed 15+ patents in the area of Non-destructive evaluation.





## NDE and Industry 4.0 for Steel Industry

**IT 25** 

THE ABSTRACT

Dr. S Balamurugan Head, Non-Destructive Testing & Sensors Research Group, R&D, Tata Steel Ltd., Jamshedpur s.balamurugan@tatasteel.com

Industry 4.0 is taking over us through a major transformation in all industries and sectors. This transformation has a multiplier effect for steel industries, as the demand for steel is on a steady growth. However, there are challenges along with these opportunities, in terms of meeting high volume production, high quality standard, and safety. Non-Destructive Evaluation (NDE) and Industry 4.0 go together in addressing these challenges for all manufacturing industries for tomorrow.

Steel industries production line has all kind of challenges varying harsh environment in terms of temperature, speed, dust, inaccessibility etc. On other side, ensuring product quality by online measurement is a mandate to meet the stringent customer requirement is another key for a sustainable. Last but not the least, ensuring safety for the production line, structures and other critical components is also the other challenge for NDE.

This talk will cover NDE as a solution for many challenges in the context of process control, product quality and safety for steel industries along with few success stories of NDE techniques in steel industry.

Keywords: Steel, NDT, Industry 4.0







#### Dr. Shivaprasad Shridhara Bhat

Advanced Research Engineer, Manufacturing Technology Centre (MTC), Coventry, United Kingdom

Dr Shivaprasad Shridhara Bhat is a non-destructive testing (NDT) researcher with over a decade of experience spanning academic and industrial R&D. He is currently with the Metrology and NDT group at the Manufacturing Technology Centre (MTC) in Coventry, United Kingdom as an Advanced Research Engineer.

He earned his MS-PhD dual degree from the Indian Institute of Technology Madras (IIT Madras), where his research focused on developing advanced numerical models for ultrasonic wave propagation in polycrystalline materials. Following this, he joined the Ultrasonics and Non-destructive Testing (UNDT) group at the University of Bristol as a post-doctoral researcher. There, he investigated ultrasonic array imaging approaches for sizing non-sharp defects and their impact on structural integrity assessments.

His work at MTC is centred on creating innovative inspection solutions for critical industries including the built environment, nuclear and aerospace sectors. His expertise spans a broad spectrum of NDT techniques, including conventional and nonlinear ultrasonics, array imaging, laser ultrasonics and numerical modelling of elastic waves in complex media. He has published over 12 peer-reviewed journal articles and 22 conference publications.





#### Automated NDT and Al-Driven Inspection of Cladded Tenanted Railway Arches

**IT 26** 

THE ABSTRACT

Dr. Shivaprasad Shridhara Bhat Advanced Research Engineer, Manufacturing Technology Centre (MTC), Coventry, United Kingdom

Railway viaduct structures are highly common across the UK and Europe, and many of the arch structures contained within them are converted into usable spaces for a range of business tenants. These so-called 'tenanted arches' have strict legal requirements to undergo regular structural inspections and maintenance, which requires direct access to the arch structure that is often cladded with either plastic or metal sheeting. Traditional examination techniques that are used during such inspections require extensive planning and manual inspection processes at a high cost, as well as causing significant disruption to tenants. This project, funded by the UK Government Department for Transport (DfT) and Innovate UK, aims to automate the inspection of cladded tenanted arches without the need to remove the cladding, and deploy Artificial Intelligence (AI) models for automated classification of surface and sub-surface structural defects. Wall climbing robotic devices coupled with Non-Destructive Testing (NDT) techniques such as Ground Penetrating Radar (GPR) and X-ray Backscatter (XBS) were deployed to build a fully digitalised and accurate view of the overall health of the tenanted arches.

The proposed automated NDT inspection methodology is capable of accurate, objective, and repeatable detection of defects within masonry structures beneath cladding materials, however, generates high volumes of data that require extensive manual image processing. Therefore, an image data processing pipeline and AI models have been deployed to automatically classify common defects observed within the brickwork, including spalling and mortar degradation. By automating the NDT inspections, developing analytical capability, and leveraging AI, this project aims to streamline the arch maintenance process, increase the quality and quantity of collected information, and improve predictive maintenance scheduling. Ultimately, this approach will provide a safer, faster, and more reliable inspection solution for cladded tenanted arches and enable more efficient data—driven decision making on the structural condition of the railway infrastructure assets.





**Diwakar Joshi**Director, QINSIGHT CONSOL PVT LTD

Mr. Diwakar Joshi, Director Insight Quality Services (working in the field of Training, Consultancy, Inspection andNDT services) and Insight Global FZE, U.A.E., is basically a mechanical engineer having more than 48 yearsexperience in QA/QC, Welding and NDT field. He has worked with prestigious organizations like WalchandnagarIndustries Ltd., Alfa Laval India Ltd., PT. Puspetindo, Indonesia and PT. Balcke-Durr Indonesia.





## NDE Training Centres – A Key Factor in Qualification And Certification Process Of NDE Personnel

**IT 27** 

THE ABSTRACT

Diwakar Joshi<sup>1</sup>,
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508, Siddharth Towers, Bldg 1/A, S. No. 12/3 B,
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In Non-destructive Testing, having qualified personnel is one of the important requirements. Training and Certification in NDE is very important for successful NDE. There are numerous national and international schemes existing to choose from. The end customer owning the ultimate responsibility of quality seems to be not involved in the process of qualification and certification. The end result of NDE is solely dependent on qualified process, calibrated equipment and qualified operator. As the other two elements can be ensured by a qualified operator, he or she plays a pivotal role in this whole process. So, the major role played in the process of good quality NDE is by the Training centres, who 'make' the certified personnel. Numerous factors may affect an operator's control on the process leading to errors. It is assumed that a 'certified' person will take care and correct the situation. However, the reality is far different. One may give a major portion of credit of the Training and Certification process to the training centres. The Training centre has to take up and monitor continuously a number of parameters to develop Quality system for controlling the overall Training function. The training centre has to ensure that the candidates will be ready to shoulder the responsibility on the field. Results of the certification examination may just be a side-product of the process. One may debate if the blame of a failed product falls on the certifying body of the person or the manufacturing company. We seldom go back to the Training certificate of the candidate to understand his capabilities. It seems the training is of no consequence once over. Having said this and understood the fact that Training centres have to own a major responsibility, an effort is made here to detail the activities required to be done by a training centre and the hurdles it needs to overcome. It includes activities like quality system design, training program design, training material, selection of trainers and so on.

**Keywords:** Non-destructive testing, qualification and certification, training centres and their role.







Dr. Ajay Pasupuleti

Ooga Technologies USA

Ajay is an entrepreneur with over 15 years' experience in image processing, data management and archival technologies. He has successfully demonstrated that he can convert concepts and ideas into revenue streams and profitable companies. As founder and CEO of Ooga Technologies he strives to bring the worldwide NDT community closer through the Ooga Platform by improving efficiencies, and ensuring knowledge is not lost through attrition and/or retirements. He received his Ph.D., in Electrical and Microsystems Engineering from Rochester Institute of Technology, Rochester NY in 2006.





#### **Entrepreneurship in NDT Industry**

**IT 28** 

Dr. Ajay Pasupuleti Ooga Technologies Inc. 4804 Page Creek Lane, Suite 223, Durham, NC 27703USA Email: info@oogatechnologies.com



The Non-Destructive Testing (NDT) and inspection market, valued at USD 10.3 billion in 2022, is projected to expand to USD 18.5 billion by 2028, reflecting a robust compound annual growth rate (CAGR) of 10.1% during this forecast period. Recent technological advancements are transforming the NDT landscape, enabling automation through digital systems, digital twins, artificial intelligence, and assisted defect recognition.

This presentation will provide a comprehensive analysis of the key drivers, constraints, opportunities, and challenges influencing the NDT and inspection market. Entrepreneurs and industry stakeholders will gain critical insights into leveraging these dynamics to foster innovation and develop strategic frameworks. By understanding the evolving landscape, participants can identify lucrative growth opportunities, tackle emerging challenges, and formulate actionable plans to position their businesses for success in this rapidly expanding sector.

Thistopic represents a pivotal opportunity for entrepreneurs to harness advancements and navigate regulatory trends, driving innovation and achieving sustainable growth in the NDT market.





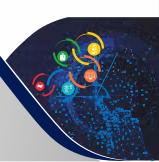


**Dr. Nishal Ramadas**Co-founder - Azeriri Pvt. Ltd. India and Hy-Met Limited UK

Dr.Nishal Ramadas is ahighly experienced engineer working in the field of ultrasonic instrumentation, with a special interest towards developing advance transducers/systems with predictive analytics capabilities. Nishal is a academic in Birmingham City University. He also co-founded two start-ups; AzeririPvt. Ltd. India (an ultrasonics transducer/system OEM) and Hy-Met Limited UK (developing instrumentation/software solutions to enable energy transition).

Nishal previously held leadership roles at Elster Metering Limited/ Honeywell, in the UK, Germany& Belgium. During his time in industry, Nishalwasalso an honorary visiting academic& a Marie Curie Research Fellow at University of Warwick UK(2011-2021). Prior to this, Nishal held post-doctoral positions at universities in the UK (Institute of Sound & Vibration-Southampton & Strathclyde University-Glasgow) and started his career as an Associate Systems Engineer at Tata Infotech Limited (Bangalore). He holds a bachelor's degree in "Medical Electronics" from Bangalore University, MSc/PhD in EEE from the University of Strathclyde (Glasgow, UK) and PG Diploma in Management/Administration from Warwick Business School (Coventry, UK).





# "Powering the future: ultrasonic NDT for inline inspection of battery quality in gigafactories"

**IT 29** 

THE ABSTRACT

Dr. Nishal Ramadas Co-founder - Azeriri Pvt. Ltd. India and Hy-Met Limited UK

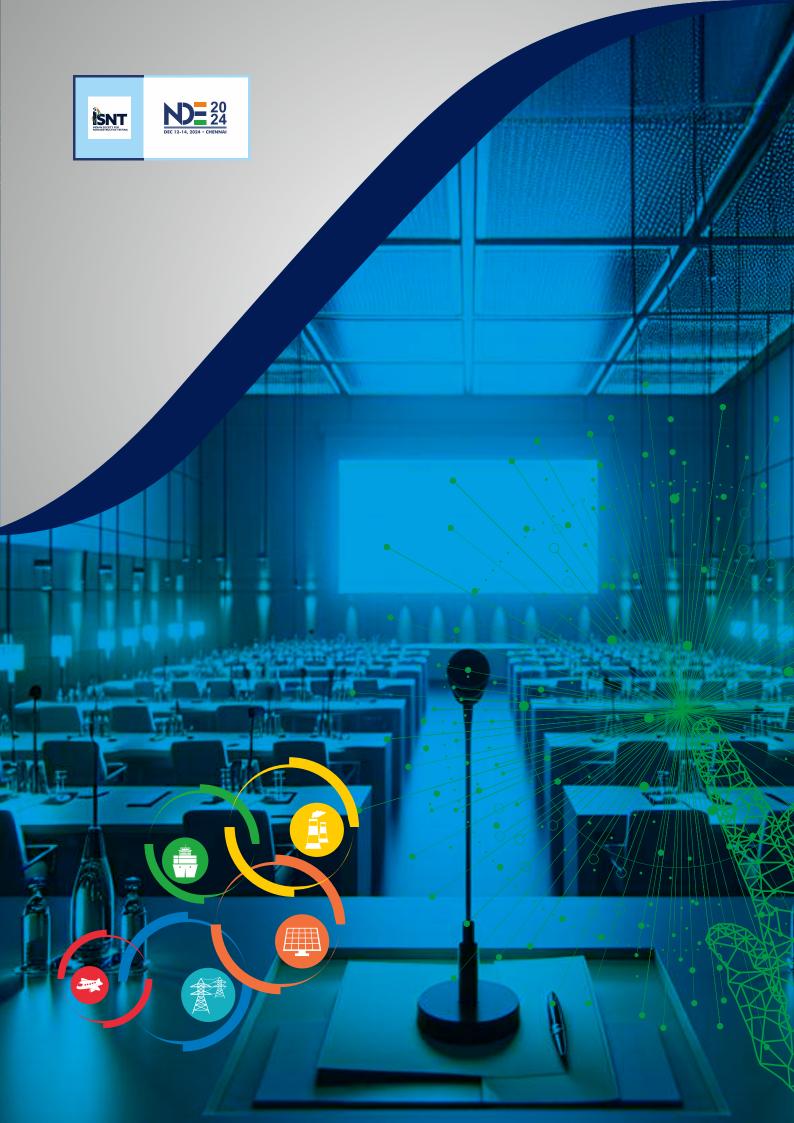
In the highly demanding environments of the refinery, petrochemical, fertilizer, chemical, and power industries, asset integrity is critical to ensuring the safety, efficiency, and longevity of critical infrastructure. One of the greatest challenges these industries face is understanding and managing the complex damage mechanisms that affect equipment such as pressure vessels, pipelines, heat exchangers, and reactors. These mechanisms—ranging from corrosion and erosion to fatigue, stress corrosion cracking, and creep—are influenced by factors like temperature, pressure, chemical exposure, and mechanical stresses, materials of construction, fabrication and welding.

A comprehensive understanding of metallurgy and corrosion with overall engineering aspect is essential for predicting the onset of these failures and damage mechanisms. Metallurgical knowledge informs material selection to resist harsh operating conditions, while corrosion expertise guides the design and implementation of effective prevention and mitigation strategies. Even with these fundamental insights, early detection and monitoring of damage mechanisms remain essential for effective plant life extension. Success in an NDT program and asset integrity relies on having precise knowledge of what to inspect, when to inspect, and how to inspect.

This presentation will explore key damage mechanisms such as HTHA, HIC, Creep, SCC and high temperature material degradation, in the context of the petrochemical, refinery, fertilizer, chemical, and power industries, highlighting how NDT techniques can be employed to detect, assess, and mitigate these threats. Case studies will demonstrate the power of combining metallurgical knowledge with advanced NDT methods to optimize asset integrity management and ensure reliable operation. By incorporating NDT expertise into routine inspection programs, industries can proactively prevent failures, reduce maintenance costs, and extend the life of critical assets.

The session will also emphasize the importance of NDT professionals' expertise, data base management and in interpreting complex data and making informed decisions based on their findings, thereby reinforcing the role of NDT as an indispensable element in the overall asset management strategy.

**Keywords:** Damage mechanisms, metallurgy, corrosion, asset integrity, Non-Destructive Testing (NDT), failure prevention, refinery, petrochemical, chemical, power industries, inspection technologies, asset life extension.





## INVITED TALKS-INDUSTRY

34<sup>th</sup>
Annual Conference & Exhibition on
NON DESTRUCTIVE
EVALUATION & ENABLING
TECHNOLOGIES

DEC 12-14, 2024 • CHENNA



#### **INDUSTRY SESSION: AEROSPACE**

Session Chair	Dr PVS Kuramanath, SDSC, SHAR			
Session Lead	Dr Debashish Mishra, GE Aerospace			
Welcome and kick off session		Dr Debasish Mishra		
Invited lecture1 : Aviation		Dr K Sriram, Principal Scientist, GE Aerospace	Composite Materials in Aircraft Engines: Challenges and Innovations in Manufacturing and Inspection	
Invited lecture 2 : Space		Sri S Harikrishna, ISRO		
Invited lecture 3 : NDT Services		Sri Shashidhar Pallaki, Pallaki NDT	The role of NDE service providers in the aerospace industry, as well as challenges and opportunities	
		Panel discussion  Inspections best practices in Aerospace to improve Product Safety/Quality		
Moderator		Mr Sujan Lingala, Global Flight Safety Leader, Product Safety and Airworthiness & Certification, Flight Safety Office, GE Aerospace		
Panelist 1		Shakti Singh, Corporate Quality, Tata Advanced Systems Ltd, India		
Panelist 2		Dr K Sriram, Principal Scientist		
Panelist 3		Sri S Harikrishna, ISRO		
Wrap up and vote of thanks		Dr PVS Kuramanath		

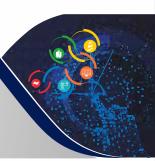


Dr. Debasish Mishra graduated from University of Roorkee with a post-graduate degree specializing in Engineering Physics. He then joined IIT Kanpur for M. Tech and Ph.D program in Nuclear Engineering. Debasish is a recipient of the prestigious Dr. K. S. Krishnan Fellowship of the Department of Atomic Energy, Govt. of India and Young Scientist Award from the Indian Science Congress Association.

Debasish worked at State University of New York (SUNY) Stony Brook as a Research Scientist and at the Idaho State University as a Research Assistant Professor. He joined at GE Global Research Center in June 2003. Currently he

leads the Non-destructive Evaluation research group at GE Global Research Centre Bangalore.

Debasish has worked in laser/optical interferometry, digital radiography, computed tomography application for non-destructive evaluation of materials.





Sujan Lingala is the Global Flight Safety Leader at GE Aerospace from the Flight Safety Office, responsible for driving flight safety initiatives across emerging global regions while supporting the global safety team. His focus is on expanding the Safety Management System (SMS) and fostering a strong safety culture, engaging both internal (Engineering, Supply Chain, MRO) and external stakeholders (Airframers, Airlines, Regulators, RSP Partners)

In his past role, Sujan Lingala was the flight safety lead for South Asia region where he served as a local advocate for product safety, liaising between the internal GE teams and external stakeholders such as regulators, airframe

customers, and airline customers in the South Asia region. Sujan's responsibilities include fostering a positive safety culture by using the Safety Management System (SMS) framework, implement strategic initiatives to enhance flight safety throughout the region, apart from developing & fostering working relationships with safety & regulatory stakeholders. Additionally, he plays a key role in collaborating with regional regulators on airworthiness & certification validation projects & investigations as per ICAO Annex-13 guidelines.

Participated in investigations with NTSB, BEA, AAIB-India, OTSB, Indian Air Force (IAF) & currently a shop investigator for the South Asia region for Annex-13 investigations

With a tenure spanning over 16.5 years at GE Aerospace, Sujan brings extensive experience in New Product Introduction (NPI) and Services Engineering. He has undertaken diverse responsibilities, including NPI design, Certification, Life Cycle Hardware ownership, and served as an Engineering manager for widebody engines for over 6 years. Sujan is a certified MRB (Materials Review Board) Mentor, a lead auditor for PPR (Priority Parts Review), and leads the SMS focal team in India. He holds a master's degree in mechanical engineering from IIT Kanpur & is a Distinguished Alumni from SNIST, Hyderabad.



Dr K Sriram is a Principal Scientist with GE Aerospace Research, specializing in the Materials Team. He holds a PhD from Cranfield University, UK, and a master's degree from the University of Sheffield, UK, both in the field of polymers and composites. Sriram is recognized as a strong technical leader with a proven track record of developing advanced composite materials and structures for a diverse range of industries, including automotive, aerospace, renewable energy, and healthcare. In his current role, he provides technical leadership in the development of lightweight and high-performance components for aircraft engines, collaborating closely with teams in systems design, engineering, manufacturing, inspection, and testing.



PVSKURMANATH, DGM, SDSC - SHAR, ISRO. SRIHARIKOTA

Joined ISRO in 1995 at SDSC-SHAR Sriharikota. Prior to joining at SHAR, had research experience in Clear Air Turbulence radars. As NDE engineer at SDSC, could able to witness and participate in the stupendous developments at ISRO and particularly in the field of NDE for solid propellant rocket motors.

Responsible for using high energy radiography of large solid rocket motors, introducing newer technologies like digital imaging and acousto- ultrasonic testing method. Responsible in establishing state of the art 9/15Mev dual energy Xray facilities for NDE of large solid rocket motors.







Mr. Shakti Singh is a Mechanical Engineer with 18 Years of experience in NDT and explicitly 15 years in Aerospace NDT. He is certified NAS 410 / EN 4179 NDT Level 3 in PT, MT, RT-Film, RT-Non Film, UT, ET and hold approvals from aerospace prime i.e. Airbus D&S, Rolls Royce etc. He is nominated as a 'Responsible NDT Level 3' for Tata Advanced Systems Ltd, its JV and subsidiaries.



Shashidhar P Pallakki is CEO and Director for Pallakki NDT Excellence Center Pvt Ltd.

Pallakki NDT Excellence Center is a NADCAP, NABL accredited, and an AS-9100 Organization located in Peenya, Bangalore catering to NDT services to many Organizations like BEML, HAL, BEL, NPCIL, VSSC, L&T, DRDO, LPSC etc...

He is NDE Level III from three international bodies (ISO 9712, ASNT and ISNT) in six differ rent methods i.e UT, RT, MT, PT, VT, and ET

ISO 9712 Level III in UT, RT, MT and PT

He is an active member of ISNT, Chairman, ISNT-Bengaluru chapter and Executive committee member for NGC (National Governing Council)



From January 2000 to August 2022 worked in the field of NDT of composite products for Spacecraft and Launch Vehicle applications.

Designed, developed and implement non-destructive test procedures for composite structural components, sub-assemblies and assemblies for enabling health assessment and prevention of anomalies at various stages of composite product realisation. Established new and innovative NDT test facilities, methods, technologies such as Automated Pulsed Thermography, Laser shearography, Air coupled and Phased array ultrasonic testing.

Along with my team, provided quality inputs in the development and use of composites products delivered by Composites Entity, VSSC and successfully flownin multiple launch vehicles and spacecraft missions of ISRO.

From August 2022 to November 2024, worked in the Quality Assurance of light alloy structures for Launch Vehicles. Worked closely with the industries. Provided solutions in making the system more operator friendly to minimise errors.

Currently designated as Deputy Director, Safety, Reliability and Quality Assurance (SRQA) of Human Space Flight Centre (HSFC), ISRO



#### INDUSTRY SESSION: NUCLEAR

Session Lead	Shri Kamalesh Kumar, NFC Hyderabad		
Keynote Speaker(s):	Shri Sundar Singh	Outstanding Scientist and Associate Director (QA), NPCIL HQ	
	Dr ParitoshNanekar	Outstanding Scientist& Head, AFD & PIED, BARCBARC, Mumbai	
	Dr Anish Kumar	Assoc. Dir, Materials Characterisation Group & Head, NDE Division IGCAR, Kalpakkam	
	Shri Kamalesh Kumar GM, NFC, Hyderabad		
	Shri V Chinnasamy	Head QA/QC/NDE, L&T Heavy Engineering IC	
	- Committee of the Comm		



Shri B. Kamalesh Kumar, is a graduate in Metallurgical Engineering from NIT, Warangal. He has undergone one year training program in Nuclear Engineering from 36th batch of BARC Training School and joined Quality Assurance group at Nuclear Fuel Complex, Hyderabad in 1993. Subsequently, he has acquired Diploma in SQC from Indian Statistical Institute and MBA from JNTU, Hyderabad. He has ISNT level -III certifications in Ultrasonic Testing and Visual Testing.

At present, he is designated as General Manager, QA (Fuels, SSTP, MI, MT & Charc lab). He has over 30 years' experience in QA of Fuels for various nuclear reactors viz. PHWR, BWR, FBTR and PFBR. He has been recipient of DAE excellence awards and has more than 25 papers to his credit.



Shri Sundar Singh, Outstanding Scientist and Associate Director (Quality Assurance) at Nuclear Power Corporation of India Limited (NPCIL) HQ, is a Graduate in Mechanical Engineering. He joined NPCIL in the year 1990 after completing one year training in Nuclear Science and Engineering from prestigious BARC Training School from 33rd Batch. He later completed his Post Graduation in Business Administration (MBA, Finance) in 1999 from Jamanalal Bajaj Institute of Management Studies, Mumbai.

He is working in Quality Assurance Directorate of NPCIL for last 35 years and handled QA activities of almost all critical Nuclear Equipment of Pressurized Heavy Water Reactors (PHWRs), Light Water Reactors (LWRs) and Prototype Fast

Breeder Reactor (PFBR) which include Reactor Pressure Vessels, Steam Generators, End Shields, Drive Mechanisms for reactor Control systems, Heavy Water Heat Exchangers etc. during manufacturing of these equipment. He has very good understanding on Quality Management System requirements for Nuclear Industry and guiding NPCIL supply chain to develop Quality Management Systems for Nuclear Requirements.

He has received many awards in NPCIL including **NPCIL Excellence Award**. Shri Sundar Singh, is certified to Level-III in various Non-Destructive Examinations which include Radiography, Ultrasonic, Magnetic Particle, Dye Penetrant and Visual Examinations.

Today, he will be talking on "NDE and its role in Nuclear Power Plants - an Indian perspective".







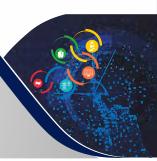
Dr. Anish Kumar is Associate Director of Materials Characterization Group and heading Non-Destructive Evaluation Division in Metallurgy and Materials Group at Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam. He obtained B.E. in Metallurgical Engineering from Bihar Institute of Technology, Sindri in 1996 and Ph.D. from IIT, Kharagpur in 2005. After one year of orientation course in nuclear science and engineering at BARC Training School, Mumbai, he joined IGCAR, Kalpakkam in 1997. In the past 27 years, he has been involved in development of advanced NDE methodologies for inspection of various critical nuclear structures & components. He worked as post-doctoral fellows at Fraunhofer Institute for NDT (IZFP), Germany as Alexander von Humboldt fellow and the University of Michigan, USA for one year each. He has about 130

publications in peer reviewed international journals, co-authored a book titled "Non-Destructive Materials Characterization and Evaluation" published by Springer Verlag, Germany and edited 2 books. He has delivered about 65 plenary/ keynote/ invited talks and seminars. He is the recipient of Science & Technology Excellence Award (2015) from Dept. of Atomic Energy, National NDT Award in R&D (2015) from Indian Society for NDT (ISNT) and several young researcher/ scientist awards from various Indian and International societies, such as Department of Atomic Energy (DAE), Indian National Academy of Engineering (INAE), Indian National Science Academy (INSA), Indian Institute of Metals (IIM), The Minerals, Metals and Materials Society (TMS-USA), International Committee for NDT (ICNDT) and ISNT. He is a member of the Editorial Board of the journal Research in NDE (the research journal of American Society for NDT). He is also a professor and members of Board of Studies of 'Engineering Sciences' and 'Interdisciplinary Science and Engineering' at Homi Bhabha National Institute. He has guided 7 PhDs and 30 Masters theses.



Dr. Paritosh Nanekar is working as a senior scientist at Bhabha Atomic Research Centre. He has over 30 years of experience in the field of Non-Destructive Evaluation, specifically related to in-service inspection of critical nuclear power plant components. He is currently heading the post irradiation examination facilities at BARC, which is responsible for assessment of metallurgical properties and failure analysis of nuclear fuel, nuclear reactor core components and several other components of nuclear plants, which form a part of primary pressure boundary. He has several research papers to his credit, specifically in the area of ultrasonic non-destructive evaluation. He also holds the position of Chairman, National Certification Board of Indian Society for Non-Destructive Testing. The Board is responsible for certification of NDT personnel as per Indian Standard (IS 13805) and ISO 9712 (ICN).





#### **INDUSTRY SESSION: EV & BATTERIES**

Session Lead	Samaresh Changdar, Waygate Technologies				
3	Name of the Speaker	Organization	Title of the talk		
Keynote Speaker(s):	Mr Robin George, Vice President	Log9 Materials	Challenges & opportunities of LiB development in India the Crucial Role of Non-Destructive Evaluation batteries inspection.		
	Dr. Raja Munusamy, Senior Vice President	Reliance India Battery R&D	The future prospect of LiB growth in India & Role of NDE for LiBmanufacturing & Quality Control		
	Mr. Ramprakash Head,	Vehicle Technology,Greencell Mobility	Current & Future Prospective of Commercial EV in India and the role of NDE		
	Dr. C V Manohar, Head	Agratas, Tata Trust, Bangalore	Current & Future prospective of LiB demand in India for mobility and the Crucial Role of Non-Destructive Evaluation batteries inspection		
	Mr. Bechir El Melki, Director Mr. Anshuman Roy, VP	MENATI,Waygate Technologies Bajaj Auto, Pune	The global transformation towards EV & H2 powered vehicles & role of NDE for manufacturing & Quality Control  Current & Future prospective of EV in India and the Crucial Role of Non-Destructive Evaluation (NDE) in the 2 wheeler EV Segment (with focus on batteries)		



Bechir El Melki is a seasoned business executive with extensive international and starategiexperiencce across blue-chip organizations.

currently, Bechir servesas a regional leader for Middle East, Africa and India, Where he leads the Waygate Technologies business delivering non-destructive testing solutions to Industrial and Energy sectors, which ensure the safety and increase productivity of our customers.

Previously, Bechir held serveral executive positions at SPX Corporaation and Invensysn/Schneider Electric, where he successfully turned around underperforming business, grew sales significantly, and established strong leadership cultures. His assignments have spanned across America, the Middle East, and Africa.

Bechir holds an Executive Leadership Formation from Indiana University's Kelley School of Business and a degree in Computer & Communication Engineering from the American University of Beirut.





#### Raja Munusamy

Expert in Hydrogen generation, Hydrogen Storage, fuel cell power system, battery technologies, Battery Management System and pioneer in automotive fuel cell technology in India with proficiency of system engineering in hybrid, battery and fuel cell EV power train technologies

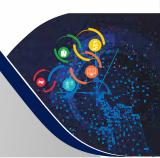


#### Robin George

As the Vice President and Chief of Climate Action at Log9 Materials, Robin George leads the research and development of innovative nanotechnology solutions for energy storage and carbon capture. With over 7 years of experience in the field, George has a strong track record of delivering impactful products, filing multiple patents, and publishing research papers in prestigious journals.

George is passionate about bridging the gap between scientific imagination and practical application, and empowering a diverse and creative team of researchers and engineers. George's vision is to leverage cutting-edge nanotechnology to address the global challenges of climate change and energy transition, and to create a sustainable and prosperous future for humanity.





#### **INDUSTRY SESSION: OIL & GAS**

Topic and Speaker	
Welcome note	Sh U Anand, Convener ISNT NDE 2024
Introduction of participants	
Advanced NDE in a Process Industry	Sh Chirag Darji, RIL
Application of NDE	Sh Devang Majithia, HPCL
Improvising NDE techniques for specific applications in process Industries	Prof. Krishnan Balasubramanian, IITM
Open forum for discussion and query	
Closeout remarks	Sh U Anand



Mr. Chirag is a mechanical engineer and has close to 17 years of experience in managing the reliability and integrity of static equipment and piping in a very large refinery and petrochemical plants. He has wide experience in application of conventional and advanced NDE method for assessing the condition of assets. He has wide interests in exploring new NDE methods that are on line and real time.



#### STUDENT SESSION

#### NDT for Career Opportunities & Enabler for Entrepreneurship

Session Lead	Dr Joseph J Kakkassery, Veltech University				
Title of the talk  NDE Overview & Career Opportunities		Name of the Speaker	Organization  IIT Madras		
		Dr Prabhu Rajagopal			
er eresti e		Dr Esha Sengupta	GE Aerospace Research		
Career Pathways in Non-Destructive Evaluation		Dr Jyotirmayee Dash	Tera Lumen Solutions		
A Journey on the less travelled		Dr Menaka	IGCAR		
Unlocking Potential: A research Scholar's path in NDE		Loheshwaran Chandran	CNDE, IITM		
	Q&A	Session			



Esha Sen Gupta is presently working in GE Aerospace Research as a Senior Scientist in the Material Systems and Inspection team. Graduated with a Masters in Physics and PhD from Max Planck Institute, Germany in the field of material science and characterization and a post-doctoral fellowship from the university of Washington. An experimental physicist engaged in the multidisciplinary areas of electromagnetics, optics, radiation physics and magnetic measurements. Devised state of the art, innovative technologies for industrial NDE solutions using simulations, experiments, and analytics

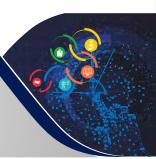


#### Dr. Jyotirmayee Dash

The first Terahertz company in India, TeraLumen Solutions, was founded and is led by Dr. Jyotirmayee Dash. She received her degree in photonics from CSIR CEERI Chennai, and she has three filed patents along with one US granted patent, in addition to publishing over thirty papers in international journals and conference proceedings.

With the mission of creating affordable, indigenous Terahertz devices that are customizable for a range of non-destructive industrial and biomedical uses, she created TeraLumen Solutions in 2019. Along with private financing from Pfizer Indovation, the company has received other renowned government awards, including NIDHI-PRAYAS from the Department of Science and Technology and BIRAC-BIG from the Department of Biotechnology. The company has successfully commercialized Terahertz devices for various industrial and research organisations.







Mr. Loheshwaran Chandran

Loheshwaran Chandran is a dedicated research scholar who completed his M.Tech in Mechanical Engineering at IIITDM Chennai in 2021 before beginning a Ph.D. at the Centre for Non-Destructive Evaluation (CNDE) at IIT Madras. Specializing in super-resolution ultrasonic imaging, he's now part of an international Joint Ph.D. program between NTU Singapore and IIT Madras, blending cutting-edge research with a global outlook.



Prof. Prabhu Rajagopal

Trained at IIT Madras (BTech & DD MTech) and Imperial College London (PhD, Postdoc), Prof. Prabhu Rajagopal has expertise in Non-Destructive Evaluation (NDE) and Structural Health Monitoring (SHM), co-leading the Center for NDE[]. With over 30 funded projects, 200+ technical articles and 33 granted IPs, he is widely recognised for his pioneering work on remote inspection technologies for digital transformation in the industrial (energy and mobility) and social (water, health and sanitation) contexts. He is recipient of India's most prestigious award for mid-career scientists, the Shanti Swarup Bhatnagar prize under the category of Technology and Innovation (2024). Prof Prabhu's research is collaborative, cross-

disciplinary and international, with ongoing engagements with industry and academic institutions across the world; particularly the UK and Kenya. At IIT Madras he is also a founding member of the Centers of Excellence in Quantum Information Communication & Computing, Cybersecurity, Trust & Reliability, and Space Manufacturing, as well as the one on Research on Startups & Risk Financing.

Prof. Prabhu is passionate about service-oriented engineering education and technology translation, cofounding several Startups (Planys, Solinas, Xyma, Plenome to name a few) that are disrupting the infrastructure maintenance space with their original offerings in digital asset integrity monitoring. Recipient of prestigious Early Career awards (National Design Award from Institution of Engineers (India), National Young Scientist Awards from: Indian Society for NDT and Institute for Smart Structures and Systems, Institute R&D Award from IIT Madras and the National Swarnajayanti Fellowship from DST, Govt of India), Prof. Prabhu is member of the Editorial Boards of international peer-reviewed journals, Ultrasonics and NDT&E International. At IIT Madras, he is the faculty in-charge of the maker space Center for Innovation and the pre-incubator Nirmaan. He is on the Advisory Board of the Techin, the Incubator of IIT Palakkad, as well as serving on their Global Sanitation Center of Excellence. Prof. Prabhu's work has also been featured widely in popular media.







Ms.Menaka, a postgraduate in physics and has over 23 years of experience in the field of NDE for materials characterization. She has specialized in the areas of thermal imaging, image processing and Digital Radiography. She is presently Heading, Radiation and Meterology Section of Radiation Application and Technology Division in Indira Gandhi Centre for Centre Research, Kalpakkam. Her field of interests are Material Characterisation using thermal NDE and Thermal imaging as diagnostic tool in healthcare. She is an ASNT certified Level – III in Infrared Thermal Testing. She has more than 70 publications in international and national journals and 80 publications in conferences. She has more than 1085 citations for her credit.

She has won the best paper awards during the IIM NMD-ATM 2005 and NDE 2007. She has also won the best paper award in the R&D Category for the paper published in Journal of NDE. She is a recipient of the Group Achievement Award of Department Atomic Energy- for the year 2009. She has been bestowed with Science and Technology Excellence Award by Department of Atomic Energy for the year 2020. She has guided more than 10 engineering and science post graduate students in their projects.

She has been an active member of ISNT Kalpakkam Chapter for over 20 years and was a member of the technical committee of 14th APCNDT. She is a member of the QIRT Asia 2015 Steering Committee and has been a regular faculty for the Level – II and Level – III courses that have been conducted by ISNT Kalpakkam.





#### PANEL DISCUSSION ON INDIAN NDT CERTFICATION

Plenary Session : II		
Hall A: BHABHA		
upta, Director, Satyakiran		
Panellist	Organization	
Dr Sajeesh Babu		
R Srikanth		
Dr ParitoshNanekar		
C M Latkar	GM, Mazagon Dock	
	Hall A: B  upta, Director, Satyakiran  Panellist  Dr Sajeesh Babu  R Srikanth  Dr ParitoshNanekar	



Dr. Sajeesh BABU has 30 years of International Experience in Energy, Refineries & Petrochemical, Oil & Gas, Building & Construction Industry in Quality Assurance & Control, NDT, Condition Monitoring & Diagnostics Testing,

Currently he is holding a position of Quality Director in Rotary Group & CEO of ANSA Holdings, Singapore

He is also the current Chairman of the International Committee for NDT (ICNDT), Vienna & the President of Non-Destructive Testing Society (Singapore).

He worked greatly for the promotion of harmonization in NDT personnel certification worldwide in specific to ISO 9712 standards

Dr. Babu obtained his Engineering Doctorate from City University of Hong Kong and obtained his Master of Engineering from University of South Australia

He is a Chartered Engineer from Singapore & UK & Registered Professional Engineer from HK respectively. He is a Qualified ISO 9712 NDT Level 3 & ASNT NDT Level 3

He is a fellow of HKICA, fellow of NDTSS, Honorary member of ICNDT & APFNDT.

He worked considerably for the promotion of harmonization in NDT personnel certification worldwide, specifically to ISO 9712 standards and developed recognition of global human resources in NDT.



Mr R Srikanth is working as "Director" with Quality Council of India (QCI)-NABL & Heading its Regional Office in Bengaluru. He holds Bachelor's Degree in Engineering from Mysore University.

He is a trained "Lead Assessor" & conducted various laboratory assessment activities as per ISO/IEC 17025 requirements, ISO 9001 from "Defence Institute of Quality Assurance (DIQA)". He is also a trained "Evaluator" for "Asia Pacific Accreditation Cooperation (APAC)" & conducted the peer evaluation of 'KAN-Indonesia' recently. He is having 30 years of professional experience including Laboratory Accreditation' activities, Calibration, Industrial QA/QC, Inspection etc. He has played a pivotal role in formulating the NABL "Specific Criteria document for Calibration Laboratories – NABL 129".







Dr. Paritosh Nanekar is working as a senior scientist at Bhabha Atomic Research Centre. He has over 30 years of experience in the field of Non-Destructive Evaluation, specifically related to in-service inspection of critical nuclear power plant components. He is currently heading the post irradiation examination facilities at BARC, which is responsible for assessment of metallurgical properties and failure analysis of nuclear fuel, nuclear reactor core components and several other components of nuclear plants, which form a part of primary pressure boundary. He has several research papers to his credit, specifically in the area of ultrasonic non-destructive evaluation. He also holds the position of Chairman, National Certification Board of Indian Society for Non-Destructive Testing. The Board is responsible for certification of NDT personnel as per Indian Standard (IS 13805) and ISO 9712 (ICN).



Mr C M Latkar

He is currently the General Manager of Quality Assurance at Mazagon Dock. A Mechanical Engineer, he began his career in 1987 with Mazagon Dock and has held various positions, including Ship Manager, Project Executive for Planning, and Project Superintendent.

He has represented Mazagon Dock in QA conclaves hosted by DGQA(N) in Mumbai, Baroda, Hyderabad, and Bengaluru. Throughout his career, he has commissioned warships of different classes, including corvettes, RE-class vessels, frigates, destroyers, and merchant ships such as Offshore Patrol Vessels (OPVs), Offshore Support Vessels (OSVs), and dredgers.









### CONTRIBUTORY PAPERS

34th Annual Conference & Exhibition on NON DESTRUCTIVE EVALUATION & ENABLING TECHNOLOGIES

DEC 12-14, 2024 • CHENNAI



### Robotic inspections of storage tanks, pressure vessels, boilers using PetroBot Robots – Field Experiences

**CP 02** 

THE ABSTRACT

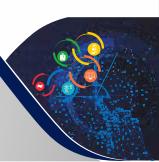
Sahab Singh Gurjar PetroBot Technologies Pvt Ltd www.petrobot.co.in

Aboveground storage tanks (ASTs), pressure vessels and boilers are very critical assets. Assuring the reliability & integrity of these assets are also very important considering the critical operations of the Oil & Gas / Chemical / petrochemical Industry / power industry. Conventional method of inspecting these assets need erection of scaffolding followed by conventional inspection by human which led to work at height hazards, confined space entries with increased safety risks. To minimise or eliminate above problems, these assets can be inspected by using online robotic tools which can go inside confined space or climb over the shell roof or dish end of these assets and can carry out the inspection of bottom ,shell / roof / dish end plates.

This paper discusses about the robotic inspection methodology, prerequisite for aforesaid inspections, inspection execution and result / finding reporting etc. This paper will benefit the industry participant to get the insights of use of tank inspection robot ATEX certified & PESO approved PetroBot ITIS Rover & ATEX compliant / PESO approved PetroBot MagRover to mitigate the corrosion failures and to monitor the corrosion damage in their tanks before it leads to disaster incidents.

**Keywords:** Robotic Inspection, pressure vessel, inline tank inspection, Boiler inspection, Robotic tank inspection, PetroBot MagRover, PetroBot ITIS Rover





### Al Flow Scanner Technology for Oman's Water Transmission Pipeline Monitoring and Management

**CP 03** 

Arthur Davis Nicholas<sup>1</sup>, Geetha Baskaran<sup>1</sup>, Divakara Shetty<sup>1</sup>, and Ahmed Al-Adwani<sup>1</sup> University of Technology and Applied Sciences, Ibri, Oman arthur.nicholas@utas.edu.om

THE ABSTRACT

Nama Water Services, the preeminent provider of integrated water and wastewater services in the Sultanate of Oman, has achieved a significant milestone in the implementation of its strategic water transport projects, bringing the nation one step closer to ensuring the sustainability of water services. However, the problem of water loss and Non-Revenue Water (NRW) has been a persistent challenge, with Oman's water supply system facing an NRW rate of approximately 40% and a yearly growing rate of 2%.Recognizing the urgency of this issue, our research team has initiated a bold plan to design, develop, and test an Artificial Intelligent flow scanner that can locate and quantify water loss and NRW across the water transmission networks in Oman. This cutting-edge solution, implemented in a 540 m length prototype pipeline network of HDPE pipes, constructed in our college premises to conduct experiments, utilizes acoustic and pressure sensors to monitor flow and pressure. The pipeline network also features six artificial leakage and six consumption points, allowing for comprehensive testing and analysis at various consumption and leaking conditions. The results of the flow, pressure, and discharge measurements, captured through a LORA-based Al-driven WiFi module, have been meticulously plotted through the Pipeline Network. Each small deviation in consumption and leakages is clearly reflected in the pressure and flow distribution, enabling the AI Flow Scanner to scan the water flow with unparalleled precision.By leveraging energy and Darcy-Weisbach equations, the research team has successfully plotted the flow, distribution, and water balance, providing a comprehensive understanding of the system's performance. This Al-powered solution is poised to revolutionize water distribution pipeline management in Oman, resolving the persistent NRW issues and ensuring the efficient and sustainable delivery of this vital resource.

Keywords: NAMA, Non-Revenue Water, Acoustic Flow Sensor, LORA, Flow Distribution



#### Wave Scattering Dynamics in Clusters of Nonlinear Solid and Elastically Hollow Inclusions

**CP 04** 

THE ABSTRACT

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Department of Mechanical Engineering,
Indian Institute of Technology Bombay, India, 400076.
mech7pkumar@gmail.com

This research investigates harmonic scattering responses in clusters of solid and elastically hollow nonlinear inclusions, inspired by micro-nano bubbles utilized in nonlinear ultrasonic contrast imaging to advance high-resolution ultrasonic imaging. This computational study comprehensively explores harmonic scattering from various configurations of nonlinear inclusions, capturing forward and back scattered waves.

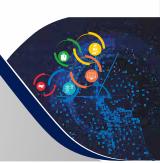
The investigation adopts a forward design approach to explore nonlinear wave manipulation capabilities through various inclusion configurations, emphasizing strategic placement to optimize interactions and scattering effects. Our investigation identifies nonlinear cloaking effects facilitated by strategically placed solid nonlinear inclusions, reiterating absence of higher harmonics and static terms with persistent fundamental longitudinal wave frequencies across different configurations.

Initially focused on solid nonlinear inclusions, our research has expanded to include elastically hollow nonlinear inclusions, representing a significant shift in approach. This novel configuration features a central circular region of linear material properties nested within a primary circular nonlinear inclusion, defining what we term as elastically hollow nonlinear inclusions. This study highlights how harmonic waves interact differently with the linear regions of elastically hollow structures. This exploration of elastically hollow nonlinear inclusions reveals distinct characteristics compared to clusters of solid nonlinear inclusions (nonlinear cloaking). Notably, the presence of second harmonics and a static term at the receiving edge contrasts sharply with responses observed in solid clusters.

Sensors strategically positioned around central inclusions capture dynamic wave propagation phenomena, including the detection of static longitudinal waves at various points. Interestingly, despite complex nonlinear interactions, transverse modes are notably absent at sensor placed at front and back of central nonlinear inclusion. Temporal and spectral responses from sensors positioned at the base and summit of central inclusions unveil insights into longitudinal and transverse wave behaviors, emphasizing overlapping patterns and delayed peak signals indicative of slower pulse speeds in transverse modes. Frequency analysis further reveals the distribution of harmonically scattered wave components and energy transfer dynamics between longitudinal and transverse modes. These findings underscore the intricate dynamics inherent in nonlinear wave phenomena within this framework.

**Keywords:** Nonlinear Ultrasonics, Harmonics Scattering, and Nonlinear Cloaking.





# Application of Image Enhancement in Pulsed Thermography Testing on Carbon Fibre Reinforced Plastic (CFRP) Sandwich Composites

**CP 05** 

THE ABSTRACT

M. B. Sobhanan<sup>1</sup>, S. Manivannan\*<sup>2</sup>, Nivish George<sup>3</sup>, Abilash<sup>3</sup>, P.Karthikeyan<sup>3</sup> <sup>1</sup>Doing PhD at National Institute of Technology, Tiruchirappalli and <sup>3</sup>working at Composites Entity, Vikram Sarabhai Space Centre, Trivandrum-695013, Kerala, India, Tel.: 9446942497, Email: mb.sobhanan@gmail.com <sup>2</sup>National Institute of Technology, Tiruchirappalli-620015, Tamil Nadu, India \*Tel.: 0431-2503616, E-mail: ksmani@nitt.edu

Non-Destructive Evaluation (NDE) plays a major role in detecting various types of defects in composite material to get confidence in the health of the composite structures. Various NDE methods have evolved based on the detectability of the various defect types and the application of the feasible test method in composites. Pulsed thermography (PT) is one of the NDE methods to appraise the quality of the thin composite monocoque and sandwich structures in the faster method with the application of automated systems. PT utilizes the transient heat of flash lamps to produce the thermal mismatch in the material during the testing operation. Anomalies in the composite material affect the heat flow characteristics through the material compared to the sound region. PT system acquires an Infrared (IR) image during the cooling or heating phase of the component during the testing operation and is recorded in a video format. Defects in the various layers of the composite materials have been indicated in different time sequences during the interpretation of IR video images for a particular acquisition time on each composite structure. Time consumption on interpretation of these recorded images is high while testing on large structures. Various image enhancement methodologies like contrast stretching, histogram equalization, logarithmic transformation, exponential transformation, power transformation, etc. are demonstrated. Defects like the absence of adhesive film and inclusion could be enhanced at the transition region between the basic to the reinforced region and the reinforced region of the composite reference specimen by image enhancement. As an additional measure to avoid missing defects and time-saving, images are represented by the integration of the various time frame images into a single image by averaging, and maximum amplitude techniques.

Keywords: Non-Destructive Evaluation, Pulsed Thermography, Composite, Infrared, Image Enhancement



## On the resilience and re-use of Spring Energized Metallic seal joints by Helium Leakage Rate measurements under Pressure and Vacuum conditions

**CP 08** 

THE ABSTRACT

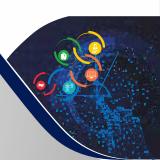
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Spring Energised Metal Seals are very attractive for achieving very low leakage rates, of the order of 1e-9 std cc/s, with low bolt tightening torques in metallic flange joints, which are exposed to highly corrosive or high temperature environments. The most successful spring materials are stainless steel, inconel and Nimonic. The resilient inner layer of the seal is generally made from one of the various grades of stainless steel or inconel. The outer sealing layer is based on the application environment - corrosive or high temperture. Aluminium and copper are routinely used, although Inconel, gold or silver also find them relevant in a few specific situations. Occasinally, coatings of Silver or Gold are made on aluminium or copper, for improving the leak tightness and the seal life. Resilience of such seals is the most important factor and the possibility of re-use is very much welcome. This work presents the measurements of the Helium Leakage Rate for a few different Spring - Inner Layer - Outer Layer combinations, using a Mass Spectrometric Leak Detector (MSLD) towards understanding the reslience and re-use of such seals under a few typical vacuum and pressure conditions. In addition to the leakage rate measurement using MSLD, a load cell was used to measure the load applied on seals and a dial gauge measured the sectional compression of the seal. Measurements were made at room temperature and pressure in the range 1e-6 to 10 bar. The relationship of the observed helium leakage rate to the applied load on the seal and the torque applied on bolts for joining the flanges are also discussed.

**Keywords:** Non-Destructive Testing, Helium Leak Testing, MSLD, Metal Seals.





### Non-Contact Magnetometric Diagnostics of Pipelines Using the Metal Magnetic Memory Method

**CP 09** 

THE ABSTRACT

Alexander DUBOV<sup>1</sup>, Sergey KOLOKOLNIKOV<sup>2\*</sup>, Mohd Noor Baharin Che KAMARUDIN<sup>4</sup>

<sup>1</sup>Energodiagnostika Co. Ltd, Moscow, Russia, mail@energodiagnostika.ru

The non-contact magnetometric diagnostics (NCMD) of buried pipelines (oil and gas pipelines, heat lines, water supply lines, etc.) has been developed by Energodiagnostika Co. Ltd. since 2000 based on the 25year experience of the metal magnetic memory (MMM) method application (ISO 24497-1:2007(E)). NCMD is based on measurement along the pipeline route of the Earth's magnetic field intensity (HEarth) distortions caused by variation of the pipe metal magnetization in stress concentration zones (SCZs) and in zones of developing corrosion-fatigue damages. The paper describes the experience of complex diagnostics of buried pipelines based on NCMD, the MMM method and conventional methods of nondestructive testing. Based on NCMD results, the most strained pipeline sections are determined for their opening and additional control by the MMM method, ultrasonic testing and other NDT methods. On opened pipeline sections the MMM method is used to determine the presence of defects and the mechanical properties of the metal by hardness parameters. Inadmissible defects are removed, and the actual mechanical properties (yield strength and ultimate strength) are taken into account in check strength calculations. The inspection should provide the answer to the following question: "Where and when should a damage or an accident be expected?". If this task is solved, then the possibility of timely replacement or repair of a potentially hazardous section is provided. Application of NCMD in combination with additional inspection of pipelines (UT, eddy current, etc.) in prospect holes determined by NCMD is aimed exactly at solution of this problem. The paper presents the experience of NCMD of buried polyurethane foam insulated pipelines in order to detect girth welded joints with developing damage.

Keywords: diagnostics, metal magnetic memory, non-destructive testing, pipeline, stress, welded joint

<sup>&</sup>lt;sup>2</sup>Energodiagnostika Co. Ltd, Moscow, Russia, serg\_kolok@mail.ru

<sup>\*</sup>Contact: serg kolok@mail.ru



### Problem of Proxy radiography of weld joints and its solution

Vikash Pratap Singh Senior Manager(NTPC Ltd) **CP 10** 

THE ABSTRACT

Non-destructive evaluation (NDE) methods, particularly radiographic testing, play a critical role in ensuring the integrity and safety of weld joints in coal-fired boilers or in any weld joints. Radiographic testing is a vital tool in the NDE for inspecting weld joints. Its ability to detect internal defects without damaging the welds ensures the safety, efficiency, and reliability of critical components specially weld joints of boiler pressure parts and other welded component of any process and non-process industry. Despite its limitations, the detailed insights provided by radiography testing make it indispensable specially in maintaining the integrity of high-pressure and high-temperature boiler pressure and non-pressure parts systems. Among the various limitations of radiographic testing (RT), proxy radiographs of weld joints are particularly critical. Any welded joints having defect and proxy radiographed submitted and reviewed in that case it has short and long-term effects on welded joints and causing huge financial losses to the industry due to forced outage of the system. To address these limitations and prevent the use of proxy radiographs, several methods are employed, including multiple inspection methods, proper training of personnel, third party inspection, and the use of check shots. These listed methods having financial implications and are time consuming. To save time and money, unknown unique identification mark method is used during sampling of weld joints along with use of advance NDE technique like phase array ultrasonic testing (PAUT), randomly or 100% depending on criticality of weld joints. Detailed procedure and its effectiveness will be explained in full article.





#### Enhancing Ultrasonic NDT Machines: Addressing Bottlenecks and Improving Inspection Efficiency

N. Bayer

**CP 11** 

**THE ABSTRACT** 

The presentation focuses on optimizing ultrasonic Non-Destructive Testing (NDT) machines to address current challenges and improve inspection efficiency within the aerospace industry. Traditional ultrasonic NDT methods are critical for ensuring the structural integrity of aerospace components but are hindered by several bottlenecks. These include reliance on single inspection machines, limited detection ranges, high operational costs, and the necessity of skilled personnel. Furthermore, NDT is often perceived as a compliance-driven nuisance, which contributes to its underutilization as a proactive tool for quality and process improvement.

To address these challenges, the presentation advocates for the integration of advanced ultrasonic techniques such as Phased Array Ultrasonics and Time-of-Flight Diffraction (TOFD). Phased Array enhances inspection capabilities by using multi-element probes to create detailed, real-time images, while TOFD provides high-resolution defect sizing, especially for crack detection. These techniques are further complemented by multi-modal NDT methods like Thermography, Eddy Current Testing, and X-ray Computed Tomography (CT). These additional methods enhance the overall inspection process by providing diverse and comprehensive data, particularly for complex and large components that are becoming more common due to advanced manufacturing techniques.

The presentation also discusses the impact of evolving manufacturing practices, which demand higher-resolution and more accurate inspections. Integrating these advanced techniques into NDT not only addresses current bottlenecks but also improves throughput and inspection quality. Moreover, by shifting the perception of NDT from a necessary burden to a strategic investment in quality management, aerospace companies can unlock its full potential. This involves emphasizing the benefits of NDT, integrating its data into continuous improvement processes, and fostering a culture that values NDT as an essential element of maintaining high standards in production.

In summary, the presentation provides a comprehensive approach to overcoming the limitations of traditional ultrasonic NDT machines by leveraging advanced techniques and changing the industry's perception of NDT.



#### Distortion and Harmonic Analysis of Magnetic Excitation Signal (DHAMES) A Simplified New Approach in Magnetic Measurements for Evaluation of Ferromagnetic Steel Components

**CP 12** 

THE ABSTRACT

Moorthy Vaidhianathasamy SAVI3M, Chennai, India vmoorthy65@gmail.com

Distortion and Harmonic Analysis of Magnetic Excitation Signal (DHAMES) is a new and simplified approach for non-destructive characterization of ferromagnetic steels. Traditional magnetic measurements such as hysteresis (B-H) loop, Magnetic Barkhausen Noise (MBN), Tangential magnetic field (Ht) measurements require secondary pick-coils and/or Hall sensors in additional to the electromagnetic yoke for magnetic excitation. DHAMES approach uses only an electromagnetic yoke and hence simplifies the sensor and the instrumentation. Due to the absence of secondary pick-up coils and field sensors, the electromagnetic yoke can be easily adopted to different component geometries like gears, bearings, spline, shafts etc. This paper explains the fundamental concepts of ferromagnetism behind the distortion phenomenon in the magnetic excitation voltage signal in the presence of a ferromagnetic sample between the poles of an electromagnetic yoke. The details of DHAMES measurements and their correlation to the magnetisation process in the ferromagnetic samples are explained in relation to the magnetic hysteresis phenomenon.

The DHAMES measurement is carried out by applying a cyclic magnetic field to a ferromagnetic sample using an electromagnetic yoke and analysing the distortion in the excitation voltage through a time derivative profile known as DAME profile. The amplitudes of the harmonics of the excitation voltage signal are also measured. A comparison of DAME profile parameters and harmonic levels can be made between a standard sample and a test sample for quality evaluation. This paper also highlights some of the applications of DHAMES method for identification of variations in heat-treated microstructures (isothermal and spheroidising annealing), variation in carbon content (0.2 % and 0.4% carbon) of steels, variations in case-depth of induction hardened, carburized and nitrided steel samples, thermal damage in roller bearings etc. as typical examples of the potential applications of DHAMES technique. DHAMES method can be used for quality control of different heat-treated components, case-hardening processes in gears, bearings and shafts, machining and grinding operations, detection of thermal ageing of ferritic steel components etc.

**Keywords:** Distortion, Harmonic analysis, magnetic excitation, ferromagnetic steels





#### **SNT-TC-1A And Its Application**

Prakash Gokulananda Director and General Manager, ASNT India

**CP 13** 

THE ABSTRACT

This presentation aims to provide a comprehensive understanding of the ASNT Recommended Practice SNT-TC-1A, which serves as a key guideline for the qualification and certification of Nondestructive Testing (NDT) personnel across various industries. SNT-TC-1A is unique in its employer-based certification model, allowing organizations the flexibility to develop their own NDT personnel qualification programs based on their specific needs.

The presentation will delve into the structure of SNT-TC-1A, including its recommendations for training, experience, examination, and certification of NDT personnel. We will discuss how the practice emphasizes an employer's role in defining qualification criteria and maintaining the records of certified personnel. The session will also explore how SNT-TC-1A differs from other global standards, such as ISO 9712 and CP-189, offering a detailed comparison to help participants understand the merits and limitations of each.

In addition to providing guidance on how to establish an effective in-house certification program, the presentation will cover the latest revisions to SNT-TC-1A and their implications for NDT operations. Practical case studies will illustrate how various industries, including aerospace, oil and gas, and manufacturing, have successfully implemented SNT-TC-1A to enhance their NDT programs.

Attendees will gain a deeper appreciation of the flexibility and responsibility that SNT-TC-1A places on employers, as well as the key factors to consider when designing and executing a certification program. This session is particularly valuable for NDT managers, trainers, HR professionals, and anyone involved in personnel qualification, ensuring that they are equipped with the knowledge to implement or improve their own certification programs in alignment with SNT-TC-1A guidelines.



#### Role of NDE in Qualification of Structural and Fuel Cladding Tubesfor Nuclear Applications

**CP 14** 

THE ABSTRACT

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With the technological advancement in extremely fast pace with synchronous efforts towards automation, robotics, artificially intelligent systems and building state-of-art manufacturing infrastructure; Non-Destructive Examination (NDE) plays a major role in this transformation as well as adapting to innovative ways. Amongst the various conventional NDE methods; Eddy Current (EC) and Ultrasonic (UT) Examination obtained a special place in general for high-tech application and nuclear industry in particular. Nuclear Fuel complex (NFC), Hyderabad manufactures structural components consists of mainly Zirconium alloys and other special grades Iron, Nickel base super alloys, Titanium alloys for nuclear, defense and space applications. Being life-time component and structural, demands high degree of reliability for the desired as-installed performance. NDE methods such UT and EC and has been widely employed for qualification of these products ensuring stringent quality requirement. In several occasions, EC and UT signals has been successfully utilized for process improvements and flaw characterization, thereby enhancing product reliability as well as material recovery. On the other hand, advanced ECE such as Array Probe technique has been deployed successfully for qualification of long length precision tubes for critical applications. Innovations in ultrasonic examination incorporating automations, introduction of high speed in-process inspection enabled prompt feedback for corrective action; thereby plays a major role in confidence building for high end applications. NDE results has been corroborated with microstructural characterization in order to ascertain root cause(s).

This paper will highlight the development of both conventional, advance NDEtechniques of UT and EC for nuclear and other critical applications. Various simulation studies carried out for establishing NDE techniques, optimizing parameters and sensor characteristics will also be discussed. Corroboration of microstructural observation with NDE results will be brought out.

Keywords: NDE, EC, UT, Zirconium Alloys and Super alloys





#### **Robotics and Automation in NDE**

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**CP 16** 

THE ABSTRACT

This paper focuses on the growing use of mobile robotics in conducting inspections and Non-Destructive Testing (NDT) across various industries, particularly in the inspection of pipelines. Regular inspections are essential to ensure the integrity and safety of infrastructure, and the use of robotics offers a modern and efficient way to carry out these inspections. The paper discusses the process of developing robotic prototypes specifically designed for industrial applications, highlighting their ability to deploy NDT systems with precision. These robots are built to reduce downtime during inspections and, in some cases, even perform NDT in real-time. This real-time capability can help avoid expensive and time-consuming shutdowns, making the process more cost-effective for businesses.

A key aspect of the paper is the focus on flexible automation in NDT. The use of automated systems combined with advanced imaging techniques allows for faster and more accurate inspection results. The paper explains how robotic systems can be integrated with nondestructive imaging technologies to reduce costs, minimize radiation exposure, and improve the overall quality of the results. By using robots, industries can perform inspections more efficiently, obtaining high-quality data in less time.

The paper provides a detailed examination of the various components of robotic NDT systems, including the process of acquiring imaging data and the evaluation of results. It also explores the feasibility of using robotic systems for NDT, demonstrating how these systems can be configured to meet the specific needs of different industrial applications. Overall, the paper highlights the significant potential of robotics and automation in enhancing the effectiveness and efficiency of NDT processes across various sectors.



# NDT Professionals Employability Outlook in Respect of Future Deployment of Automation, Artificial Intelligence and Machine Learning in the Service Industry.

THE ABSTRACT

**CP 17** 

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NDE 4.0 inNon-Destructive Testing (NDT) is being taking shape by various researches, which incorporates sophisticated algorithms and enhanced automation to reduce the need for human input and, consequently avoids the likelihood of human error. This development aims to increase workplace safety and the dependability of automated inspection procedures. For example, the oil and gas sector heavily relies on Non-Destructive Testing (NDT) inspection techniques to guarantee the safe operation of its plants. Numerous inspection personnel are employed to assess the operational status of active plants and ensure the quality of products in manufacturing facilities, thus preventing unforeseen shutdowns. However, the precision and dependability of outcomes are subject to the interpretational expertise of NDT technicians. The emergence of artificial intelligence (AI) and machine learning (ML) presents employers with an unprecedented opportunity to mitigate inaccuracies and the lack of probability of detection (POD), historically attributed to human error. On the contrary, it is evident that the introduction of NDE 4.0 will lead to an escalation of structural unemployment. Hence, in this context, the inquiry pertains to the potential employment prospects for NDT technicians if they were to be supplanted by AI and ML technologies. Thus, with this rapidly evolving AI and ML in the NDT sector, it is challenging to foresee the industry's future trajectory. This paper aims to address the potential challenge of structural unemployment following the successful implementation of NDE 4.0. The primary objective is to provide insights on how to ensure the sustained employability of NDT professionals in response to this development. Moreover, this market dynamism, on the one hand, leads to the discontinuation of specific job roles while also giving rise to new and varied employment opportunities.

Keywords: Employability; Automation; NDT professional; Inaccuracy; Probability of Detection.





### Heat Exchanger And Boiler Tube Inspection Using Apris

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**CP 18** 

THE ABSTRACT

Acoustic Pulse Reflectometry (APR) has been applied extensively to tubular systems in research laboratories, for purposes of measuring input impedance, bore reconstruction, and fault detection. Industrial applications have been mentioned in the literature, though they have not been widely implemented.

Academic APR systems are extremely bulky, often employing source tubes of six meters in length, which limits their industrial use severely. Furthermore, leak detection methods described in the literature are based on indirect methods, by carrying out bore reconstruction and finding discrepancies between the expected and reconstructed bore.

Here, we describe an APR system which is named APRIS designed specifically for detecting faults commonly found in industrial tube systems such as heat exchangers, condensers and boilers: leaks, increases in internal diameter caused by wall thinning due to pitting & erosion, and constrictions (i.e.,) blockages or deposits or scales.

The system employs a transceiver that comprises of one loudspeaker and two microphone, making it extremely portable, but creating a large degree of overlap between forward and backward propagating waves in the system. A series of patented algorithmic innovations enable the system to perform the wave separation mathematically, and then identify the above faults easily, with a measurement time on the order of 10 seconds per tube. The greatest advantage of sound propagation using air as a medium let the technology to inspect tubes of any shapes and any material.

We present several case studies of tube inspection in a boiler, air fin cooler, twisted tube heat exchanger, power plant condenser, HP/LP heaters, showing how different faults are identified and reported.

**Keywords:** Acoustic Methods, Heat Exchanger Tubing, Boiler, Tubing, Advanced Tube Inspection, User friendly operation



### "Development of a novel laser assisted alignment procedure for the erection of EOT cranes".

**CP 19** 

THE ABSTRACT

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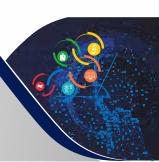
One of the critical factors influencing the performance of EOT (electric overhead travelling) cranes is the alignment of rails. Proper rail alignment is essential for ensuring satisfactory performance, extending the crane's lifespan, and preventing serious accidents, such as derailing and crane collapses. Achieving correct alignment involves maintaining parallelism, straightness, level, and proper elevation during both installation and maintenance of the cranes.

The degree of alignment can be assessed by examining the span of crane rails, the relative level of each rail, and the parallelism between them. According to BS 466, a tolerance of 3mm is allowed for the crane rails with a span length of 15m or less. For spans greater than 15 m, the tolerance is 3+0.25(s-15) mm, whereas represents the span. Additionally, a maximum tolerance of 10 mm from the datum is allowed for the straightness of the rails over the entire bay length, with a cap of 1 mm per 2000 mm of rail length. Rail elevation tolerance in the vertical plane is limited to 0.001 times the span length in millimetres, with a maximum of 10 mm for the entire bay length. The permissible transverse inclination is restricted to be  $\leq 1$  mm over a 300 mm length of the rail.

Meeting these stringent alignment requirements, especially at higher elevations, typically involves sophisticated optical instruments like Jig Transit. However, handling, transporting, and setting up such devices can be complex and impractical in a running plant. These challenges can be mitigated by using a simpler laser-based alignment device. This technical paper explores the standardization and implementation of a laser-assisted alignment procedure, which effectively facilitates the rail alignment process.

Keywords: EOT crane, straightness, rail alignment, span length and laser instrument





#### Accelerating The Total Focusing Method using Sparse Arrays with n<sup>th</sup> Coherence Factor Weighted Delay and Sum Beamforming

**CP 20** 

THE ABSTRACT

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The total focusing method (TFM) is a well-known approach for NDT applications. In TFM, each element of the ultrasound probe is sequentially excited, and the scattered signals from the mediumare received by all elements. The data is stored using the full matrix capture (FMC) process. Data from each firing is processed with delay and sum beamforming (DAS) to form low-resolution NDT images, which are then combined to form higher resolution NDT images. This process is computationally intensive. We suggest an advanced beamforming method, nth coherence factor weighted DAS with sparse arraysto accelerate the TFM imaging process. Grating lobe artifacts are typically associated with sparse array imaging and can be reduced with advanced beamforming methods. The coherence factor (CF) is the ratio of coherence sum energy from delay and sum output to incoherent sum energy of the element signals. This factor was weighted to delay and sum beamformed output. The nth power was raised to CF to enhance the beamforming process's sensitivity. To assess the efficacy of an advanced beamforming algorithm, an aluminum block was used in both vertical and horizontal block positions (VBP and HBP), with five defects separated by 30 mm axially. Each probe element (5L64-11) with a center frequency of 5 MHz, 64 elements, and 0.6 mm element pitch was excited sequentially, and the scattered signals were obtained using all the elements and processed offline using the proposed beamforming method. We assessed the CNR for standard (64 elements) and sparse (8 elements) imaging and compared to each other. For VBP and HBP, nCFwDAS (n = 3) improved the CNR of the lowest target by 7.36 dB and 14.6 dB relative to DAS. For the sparse array imaging, improvement was within 3 dB relative to the performance obtained with 64 elements. These findings underscore using a proposed algorithm to speed up the TFM imaging process with only eight elements.

Keywords: Total focusing method, delay and sum beamforming, coherence factor



### GPR Inspection of Concrete for Delamination Detection, Mapping and Localisation

**CP 23** 

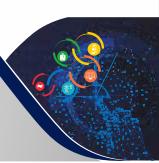
THE ABSTRACT

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Delamination in concrete pose significant risks to structural integrity and longevity, mandating early detection crucial for preventive actions and maintenance. Material degradation during service and poor construction practices are the root causes of delamination. Destructive tests cannot be performed for subsurface defect detection because they compromise structural integrity and usability. Therefore, concrete inspection includes a variety of nondestructive tests for interior evaluation. Since concrete constructions often have access to only one side, inspection can only be accomplished using techniques such as ground penetrating radar and ultrasound. The latter involves transmitting electromagnetic waves and capturing the reflected signals from interior objects. The behavior of the signal changes depending on the dielectric constant of the materials encountered; materials with higher dielectric constants produce stronger reflections. A radargram visualizes the subsurface features by displaying these reflections in time or depth dimensions. Delaminations as air-filled defects, cause changes in dielectric constants, and allow effective detection of anomalies. In this study, polyurethane foams were used to cast a reinforced concrete slab  $(1 \times 1 \times 0.18 \text{ (m)})$  with delamination in three separate locations at a depth of 100 mm. A ground penetrating radar of 2 GHz center frequency is utilized for inspection on the outer surface, and multiple line scans were acquired and then stacked together in the form of a radargram. These radargrams were used to construct 3D mapping of slab and image delaminations and defects. Rebars were also traced with multiple hyperbolic signatures as characteristics of point reflectors. Delaminations were successfully traced as lines of finite length were feasibly localized.

Keywords: Concrete, Delamination, NDT, GPR.





#### Non-Destructive Examination of Actively Cooled High Heat Flux Components Produced by Vacuum Brazing

**CP 24** 

THE ABSTRACT

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In experiments at the Institute for Plasma Research (IPR), several components, including the multi-aperture extractor grid segment, experience substantial heat flux ranging from several tens of kilowatts to megawatts. The extractor grid, designed for extracting negative ion beams at a potential of 11 kV, is subjected to a heat flux in the range of  $6-10\,\text{MW/m}^2$ . To manage this, the grid is actively cooled using water. The cooling water flows through embedded channels at a high pressure of 10-15 bar, while the grid plate is situated in a vacuum environment with a pressure of approximately 10-6 mbar.

The cooling channels embedded in the grid plate are manufactured using vacuum brazing, a process that must be verified using non-destructive examination techniques to ensure its integrity. The grid plate must meet stringent leak rate requirements: around  $5 \times 10-09$  mbar-lit/sec in vacuum mode using tracer probe techniques and about  $1 \times 10-07$  mbar-lit/sec in vacuum mode through pressure techniques.

To ensure the grid plate meets operational standards, a thorough inspection and testing procedure is implemented. This includes localized helium leak testing with a Mass Spectrometer Leak Detector (MSLD) at both room and elevated temperatures using vacuum hood tracer probe methods, as well as integrated helium leak testing with MSLD by pressure hood methods under similar conditions. Additional tests include dry nitrogen pressure testing and infrared thermography. The vacuum and pressure tests are conducted in compliance with ASME code requirements and the guidelines outlined in the ITER vacuum handbook. During acceptance testing, the grid plate is placed in a high vacuum environment, and helium is pressurized through the cooling channels at operational pressures of 10 bar and elevated temperatures of approximately 100°C. This process simulates the actual conditions the grid will experience during operation.

This paper outlines the detailed testing and acceptance procedures employed to ensure the reliability and quality of the fabricated components, specifically focusing on the characterization of the grid plate to meet operational standards.

**Keywords:** MSLD Leak testing, vacuum brazing, Nondestructive examination



### Non-Destructive Examination & Testing of Integrated Vacuum Vessel Components

**CP 25** 

THE ABSTRACT

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Integrated vacuum vessel of LI-VISTA facility is recently being setup at Institute for Plasma research Gandhinagar. Vacuum vessel of 1240 mm ID, 10 m length is fabricated (2 nos) using combination of circumferential and Longitudinal seam welding from SS304 L HRAP material of thickness 3.2 mm. Vacuum vessel of LI-VISTA facility is being developed to assess fabrication feasibility of thin section ,large diameter tubular pipe with Stringent dimensional control, Control Heat input in TIG welding, risk & damage assessment in handling, transportation, Demonstration of UHV performance in ≤ 10-9 mbar range.

This prototype fabrication is part of technology development for  $4 \, \text{Km} \, \text{x} \, 2 \, \text{Nos.}$  of Beam tube of LIGO India project. SS304L HRAP coil used for fabrication of vacuum vessel were air baked at  $440 \pm 8$  °C to have uniform oxide layer on the steel surfaces to minimizing the hydrogen out-gassing rate, Contamination control procedure was established at shop floor required for UHV performance of vacuum vessel, Air baked plates were Rolled and longitudinal seam of shell was TIG welded with control heat input with SPM and subsequently vacuum and support stiffener were welded externally, Various shell segments dry machined on SPM to get the flatness and perpendicularity in 0.25 mm and Circumferential seam welded to get he vacuum vessel length of 10 m.

Fabricated vessel was dimensionally examined including flatness, perpendicularity was within 0.25 mm and straightness was 2.8 mm over length of 10 m. A special cleaning procedure was adopted for cleaning of vacuum surfaces to ensure UHV performance, cleaned surfaces was examined by UV light source and by FTIR analysis to assess its cleanliness, each weld joints was subjected to Helium leak testing and demonstrated the  $\leq 1 \times 10$ -10 mbar l/s individual helium leak rate and  $\leq 1 \times 10$ -9 mbar l/s for Gross helium leak rate of 10 m vacuum vessel in vacuum mode. Integrated vacuum vessel assembly was pumped down to demonstrate the vacuum inside the vessel and demonstrated the vacuum up to  $\sim 5 \times 10$ -9 mbar so far.

Keyword: Vacuum, Leak Testing, Air Baking, UV Light, SS304L

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# Application of derivative based methodology for accurate estimation of TOA (Time of Arrival) along with distinguishing multiple loose parts on structure for Loose Part Monitoring System

**CP 26** 

THE ABSTRACT

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In recent times there has been an increased need to monitor the structures for presence of any impacting objects, while the fluid is in operating condition. There have been events being reported, where in loosened part of the structure has been repeatedly impacting and also audible noise is generated due to the impact. Repetitive impacts caused by the loosened part can cause structural damage and malfunction of some of the critical components. In view of this, development of a diagnostic system known as Loose Part Monitoring System has been necessitated, to monitor the structures during operation for presence of any impacting objects, by estimating there locations and suitably effectuating necessary modifications.

In order to estimate the location of an impacting loosened part on a structure, it is imperative to accurately estimate the delay in Time of Arrivals between the impact signals to number of mounted accelerometers on a large structure. For a substantial determination of time delay, it is indispensible step to be able to read the peak of the cross correlation function precisely, which has been carried out by efficiently applying the derivative based methodology for accurately estimating the time delay.

Furthermore it is important to clearly identify and distinguish between multiple impacts caused at a single location on structure, from the impacts at multiple locations on the structure uniquely. This aids in taking prudent corrective actions vis-à-vis to the structure. The current paper discusses and demonstrates a better and more robust form of estimation time delay along with the proposed methodology to uniquely determine the impact locations on a large structure with by determining and distinguishing between multiple impacts caused at a single location on structure, from the impacts at multiple locations on the structure uniquely. Investigated Structure was projected on a cylindrical coordinate system and locations of the impacting loose parts were estimated using cylindrical coordinates.



### Enhancing NDE with Digital Ecosystems: Bridging Gaps in Procurement, Training, and Asset Management

**CP 27** 

THE ABSTRACT

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Our platform is designed to transform the Non-Destructive Testing (NDT) and Evaluation (NDE) industry by creating a unified, digital ecosystem that improves access to essential tools, training, and career opportunities while enhancing operational efficiency and asset integrity management. Although the NDT market is valued at \$21 billion, its fragmentation leads to inefficiencies in hiring, asset integrity, and procurement. The market, projected to grow to \$30 billion by 2029 (Mordor Intelligence) (FMI Research) will continue to be hampered by these issues without a consolidated solution.

Our platform addresses this by offering a comprehensive solution across three pillars: a marketplace for devices and consumables, a hub for learning and certification, and a talent connect portal. The platform caters to the specific needs of NDE professionals by integrating digital technologies to streamline procurement, operational processes, and career development, while also addressing current pain points like poor matching algorithms and high recruitment costs.

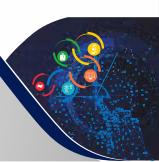
The NDE market is estimated to be segmented into four key verticals: Services, Inspection, and Monitoring (40-45% market share), Manufacturing Equipment and Goods (25-30%), Training and Certifications (10-15%), and Automation and Systems (15-20%). Our marketplace enables direct interactions between buyers and manufacturers, reducing inefficiencies and ensuring access to both high-end complex equipment and low-cost consumables. Additionally, the platform offers structured training and certification programs, fostering continuous professional education and skills development.

Operational challenges, such as manual inspection processes, fragmented job search platforms, record-keeping errors, and inadequate traceability, impede the industry's growth. Our platform digitizes these processes, ensuring compliance with industry standards such as ISO 17025 and enhancing inspection quality.

Aligned with Industry 4.0 and NDE 4.0 principles, our platform integrates automation, AI, and data analytics into NDE processes, fostering innovation and improving resource allocation. By offering global reach and specialized features, the platform supports career growth and addresses regional gaps in emerging markets. It also plays a crucial role in certification and training, contributing to the global growth of NDE by supporting continuous professional development. By democratizing innovation, we aim to transform the NDE sector, empowering professionals to thrive in an evolving global market.

**Keywords:** Digitalisation, Asset Integrity, NDE4.0, Workflow Management, Industry 4.0, Marketplace, Training and Certification, Operational Efficiencies.





#### Nonlinear Guided Waves for Debond Imaging in FRP-Strengthened Concrete Beams

**CP 28** 

THE ABSTRACT

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Structural integrity is crucial for ensuring the safety and longevity of reinforced concrete elements. This study investigates the issue of debonding in FRP-strengthened concrete beams, utilising nonlinear features of guided waves for enhanced damage detection and quantification. Fiber Reinforced Polymer (FRP) composites are widely utilized in structural strengthening due to their high strength-to-weight ratio and resistance to environmental degradation. However, debonding at the interface between the FRP and concrete poses a significant threat to structural performance, potentially leading to catastrophic failures if not detected early.

Traditional linear ultrasonic methods often lack the sensitivity required to identify early-stage debonding, which can result in delayed maintenance and increased repair costs. In this research, an advanced nonlinear guided wave-based method is proposed, focusing specifically on higher harmonic generation, to improve detection capabilities. A mixed frequency pulse is utilized for excitation, enhancing the propagation of energy through the material and improving the sensitivity of the measurements.

To visualize the debonded regions, a synthetic 2D grid is prepared from multiple pitch-catch paths, taking into account various debonding scenarios to ensure comprehensive analysis. The Intersection over Union (IoU) technique is employed to quantify the accuracy of the detected debond areas by comparing them with known defect locations, thus providing a reliable metric for evaluating the effectiveness of the proposed method.

The results of this study demonstrate that nonlinear guided waves present an effective approach for both quantifying and imaging debonding in FRP-strengthened concrete beams. This research ultimately aims to enhance non-destructive evaluation (NDE), contributing to safer and more resilient infrastructure.



### Helium Leakage Measurement in a Set up for Permeation Rate Study

**CP 29** 

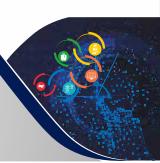
THE ABSTRACT

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This paper presents the NDT Helium Leak Testing method and observations made in a setup designed for permeation rate measurement. The permeation rates of a few selected metal and elastomer diaphragms are of extreme importance to Vacuum system designers in the area of nuclear, space and pharmaceautical applications. Most usefully, permeation rates are required to be measured in the range of 10-3 to 10-10 std cc s-1 cm-2 bar-1. To achieve this, two high vacuum chambers - Source and Destination, capable of reaching UHV and interconnected with features for introducing a permeating membrane, are fabricated. Each chamber is equipped with multiple ports and joints (200 CF, 35 CF, 63 CF, 16 KF, and 25 KF) to accommodate diverse experimental needs. Evacuation is achieved using a high-vacuum turbo molecular pump with a capacity of 400 l/s, paired with a rotary backing pump rated at 12 m<sup>3</sup>/h. Additionally, an ultrahigh vacuum pump operating with a non-evaporable getter is utilized whenever a vacuum level better than 1e-9 mbar is required. An ultimate vacuum better than 1e-9 mbar is achieved in both the chambers of system. Each chamber is fitted with isolation gate valves to maintain vacuum integrity, along with high vacuum gauges for accurate pressure monitoring. The system is designed for rough, low, and high vacuum modes of operations. Helium is utilized as a tracer gas for leak detection, enabling the detection of small leaks critical for assessing the system performance. The findings improve the effectiveness of the setup in achieving stable vacuum conditions, thereby enhancing the reliability of permeation rate measurements. The Mass Spectrometric Leak Detector (MSLD) is also utilized in the characterization of Helium permeation through the barriers.

Keywords: Non-Destructive Testing, Helium Leak Testing, MSLD, Permeation Measurement.





## An adaptive approach of the total focusing method for the inspection of parts with a complex shape

**CP 30** 

THE ABSTRACT

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Total focusing methods such as SAFT, TFM and AFM are becoming standard in the nondestructive testing industry, as they generally give better image quality than conventional phased array ultrasound. Since all TFM methods are time-based approaches they provide excellent results, as long as the geometry and the acoustic properties of the material are well known. In reality, there are often cases where the characteristics of the part being tested, such as the geometry, are not well known. In this paper, we propose an adaptive approach of the total focusing method (ATFM) in order to take into account a complex specimen shape. ATFM requires a single data set for a single image and does not need multiple acquisitions to detect the surface profile, which becomes preserved in the B-Scan images as no beam correction is needed. We show different applications and results of ATFM (and APWI), and how these adaptive methods can detect the surface profile of the specimen under test and generate high-quality images, both in real-time and off-line. Real examples from the inspection of diverse materials containing various flaws are presented as well, demonstrating how ATFM can overcome ultrasonic coupling issues derived from complex or unknown geometries/positions.

Keywords: TFM, PWI, UT, PAUT, ATFM, Adaptive coupling

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### Ultrasonic Evaluation of Explosion Welded Joint with SS-Cu-Al

**CP 31** 

THE ABSTRACT

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In recent years, the dissimilar metal bonding has found considerable applications in the nuclear, electronics and aerospace industries. Various Non-Destructive Testing (NDT) methods are being developed for evaluation of bond quality of such types of joints. This study is extension to the same efforts. In the present work, explosion welded sample with joint configuration SS-Cu-Al is inspected using manual contact normal beam Ultrasonic Testing method. Job consist of two metal to metal interface i.e., SS-Cu & AL-Cu. Signal amplitude from joint interface is observed for evaluation of bond quality. Amplitude of signal is propotional to size of defect. Continuous signal from joint interface due to impedence difference was deciding factor for setting sensitivity for UT evaluation.

For sensitivity calibration, acalibration block of similar configuration (SS-Cu-Al) was used. Flat Bottom Holes (FBHs) of different sizes and depths were made from both i.e., SS and Al sides. Separate sensitivity calibration parameters were used for scanning from either side. Scanning was done with 50% overlap using single crystal ultrasonic probe of diameter 6.25mm and frequency 5MHz. SS-Cu interface was inspected from SS side whereas Cu-Al interface was inspected from Al side.

Wherever amplitude of signal from metal interface exceeds that of amplitude of signal from physical FBH, virtual FBH (from calculation) was used. Effective size of virtual FBH was calculated using physical FBH present in calibration block (using reflector sizevs amplitude of signal graph) and Gain value for establishing sensitivity requirement.

No flaw greater than Ø 3mm from SS-Cu interface and Ø 4mm from Al-Cu interface were observed.

Keywords: Impedence mismatch, Ultrasonic test for joint of dissimilar material, explosion welding.





### Study of NDE Imaging Qualities of High-Energy RT System

**CP 32** 

THE ABSTRACT

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Radiographic Testing (RT) investigation of thick and dense objects is often required to be employed in nuclear and other fields for Non-destructive Evaluation (NDE). for this purpose, high energy sources are required. For high-energy radiographyaccelerator based X-radiation sources like linear accelerator (LINAC) or betatron are used in NDT applications. Cobalt-60 (Co-60) is the most widely usedsource of gamma radiation. Recently a High Energy Radiation Application (HERA) facility with a betatron based 7 MeV X-Ray RT System and a gamma RT system with Co-60 sealed radioisotope source has been setup at Industrial Tomography and Instrumentation Section (ITIS), Radiochemistry and Isotope Group (RCIG), Bhabha Atomic Research Centre (BARC). These newly installed systemsareintended to be utilized for the examination of thicker and/or higher density industrial components, assemblies and structures.

This paper presents initial experiments to study NDE imaging quality of the high-energy RT system to obtain images that are suitable for NDT test requirements. A 110 mm thick steel block with slots of different size has been specially fabricated to carry out the experiments. Exposures were taken at 7 MeV energy, current of 1.12 A. and source-todetector of about 800 mm. Radiographic quality has been evaluated using Image Quality Indicators (IQIs). Wire-type and hole-type IQIs were selected depending on the penetrated thickness. Experimental results show that the contrast sensitivity of about 2% or better has been achieved which is the requirement for majority NDE inspection standards. Image analysis reveal different prefabricated slots in the specimen. The facility will significantly augment the in-house quality control capabilitywithin BARC.

Keywords: Radiography testing, Non-destructive Evaluation (NDE), high-energy RT System, betatron



# Development of an FDTD tool for wave propagation simulations in 3D polycrystals

**CP 33** 

THE ABSTRACT

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We report the development of a stable rotated staggered FDTD scheme to simulate wave propagation in 3D polycrystals. Polycrystals of prescribed grain size distributions and orientational distributions were generated using NEPER.

While CPU computing with large number of cores gives results in a reasonable time, it is found that GPU computing is significantly quicker than CPU computing for simulating elastic wave propagation in a polycrystal. However, polycrystal generation, particularly when the mean grain size is a few tens of microns, and the sample size is a few mm, turns out to be a bottleneck in both NEPER and DREAM 3D software tools. The wave propagation simulation tool facilitates the exploration of a wide range of scenarios.

Wave propagation simulations have been successfully tested in homogeneous and isotropic media, homogeneous anisotropic media, and polycrystalline media.

Ultrasonic pulsed signals with center frequencies of 2 MHz, 5 MHz, and 10 MHz have been used for simulations in polycrystals through contact mode of transduction and reception.

It is known that the back-scattered signals from the grains of the polycrystal can, depending on the grain sizes and the probe frequencies, mask the scattered signal from an FBH. Preliminary studies were carried out to simulate the response from flat-bottom-holes (FBHs) of various diameters located on the back-wall of a polycrystal. The trends seen in the simulations for Nickel superalloy are found to follow the experimental observations.

Further work is underway to carry out simulations taking into account statistical variations in grain sizes on the one hand and to incorporate additional features such as two-phase polycrystals on the other.

Keywords: Ultrasonic Testing, FBH, Polycrystals, Nickel superalloy, Finite Difference Time Domain (FDTD),

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## Regaining the lost capacity of Boilers in power plant using NDE techniques

Dr. R. J. Pardikar TWI (INDIA) PVT.LTD **CP 35** 

THE ABSTRACT

Pressure parts of fossil fuel power plant boiler-operating at high temperature and pressure are designed for finite life. Depending on the actual operating and environmental conditions, material properties of boilers components degrade as a function of service life due to one or more of time dependent material damage mechanisms such as creep, fatigue, corrosion, erosion, etc. The outages in the boiler can be attributed to water wall/super-heater/re-heater tube failures, damage to critical high temperature headers and piping system, economiser leakage and operational problems.

Non-destructive Evaluation is one of the most important technical means of demonstrating that the power plant has the required margins on its structural integrity to allow further operation. The information gained from NDE would be used in conjunction with data on material ageing, stress and failure analysis before making any decision on continued operation. In addition to the routine NDT checks like MPI, LPI, UT etc., for assessment of soundness of welds and replication technique for evaluation of micro-structural degradation, there is need for development of special NDT techniques. High sensitivity defect detection and characterization in weldments of critical boiler components. continue to evoke sustained interest. Advanced NDE techniques such as Acoustic Emission, Holography, Thermography, Digital and Computed Radiography are being employed to meet the challenging demands posed by new materials and critical welds. We will be seeing increasing usage of ultrasonic sizing techniques like Time-of-flight Diffraction (TOFD), Ultrasonic Phased Array Technique (PAUT) and Magnetic Barkhausen Noise (MBN) etc for residual life assessment of components. The advanced NDE techniques will help in early detection of critical defects and in making better evaluation of useful life of components based on which run/repair/replace/retire decisions can be arrived at.



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## Non-Contact Nondestructive Testing for Characterizing Low Velocity Impact Damage in Composite Structures

**CP 36** 

THE ABSTRACT

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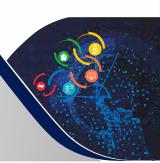
CSIR-NAL, is a pioneer laboratory in the use of Carbon Fiber Reinforced Polymer (CFRP) materials for the principal structural elements of developmental aircraft. Despite having wide spread advantages, CFRP structures are sensitive for damagessuch as barely visible impact damages (BVID) caused by low velocity impact leading to potential threat to airframe structural integrity. Evolution of nondestructive evaluation methodologies for the maintenance of CFRP structures are in continuous development due to the complexity of damage mechanics of low velocity impact.

In this study, two different non-contact NDT techniques were used for characterization of such BVID. A guided wave based damage detection techniquewas used with Scanning Laser Doppler Vibrometer (SLDV) for detection of Lamb waves in non-contact manner and excitation of guided waves was carried out by piezo actuators. A low frequency fundamental antisymmetric mode ( $A0\sim25-50~kHz$ ) of guided wave was used as interrogation signal. Further, for reference purpose Air-coupled ultrasonic testing (ACUT) technique was used in the same panel of dimension  $150\times100\times1.5~mm$ .

Measured root mean square (RMS) map of out of plane velocities at the scanned points of guided wave were plotted with respect to the dimension of the CFRP panel. Through transmission ACUT C-scan of map for panel using focused ultrasonic beam, with a center frequency (f) 140 kHz with a gain of G=70 dBwas used to generate C-Scan map. RMS map measured by SLDV technique reveals the shape and approximate size of the BVID which manifested good correlation with ACUT C-scan map.

Keywords: Composites, BVID, Scanning Laser Doppler Vibrometer, Air-coupled ultrasonic testing





#### An Ultrasonic Figure of Merit Perspective for Airworthiness Qualification of High Pressure Turbine Rotors

**CP 37** 

THE ABSTRACT

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Ultrasonic inspection using immersion technique is one of the main non-destructive inspection techniques usually employed for airworthiness qualification of high pressure turbine rotors. Typically, products with thickness of over 12.7 mm are qualified against AMS 2630E standard. As per AMS 2630E, the dimensions of linear discontinuities (in terms of flat bottom hole diameter (FBH)) which should be considered for defining the quality class as well as the permissible loss of back reflection is indicated. Needless to say in terms of designer's perspective, it is always more the merrier. Hence, the qualification of the material is always demanded at a very stringent condition, i.e., smallest possible flat bottom hole or linear discontinuity size. Important contribution of microstructure morphology, specifically grain size on the grain noise and its subsequent effect of FBH detectability is not indicated explicitly in any of the AMS standard. This would result in enormous limitations while identifying the suitable FBH against which the material is expected to be qualified.

In this study, an ultrasonic figure of merit perspective was utilized for assessing the inspect-ability of sonic forgings against a quality class. High pressure turbine (HPT) forgings made of medium alloyed nickel base superalloy DMR SN 742 are subjected to immersion ultrasonic testing based qualification. Effect of grain size on the grain noise and eventual detectability of FBH is established using samples with variation in grain size. It is demonstrated that for the grain size in consideration for the HPT rotors, ultrasonic qualification against the smallest possible FBH as per AMS is not practically feasible.

Keywords: Ultrasonic Testing, DMRSN-742, Flat Bottom Hole, Airworthiness, Quality Class



### Radiography Inspection of Weld on Pipe using Flexible Detectors

**CP 38** 

THE ABSTRACT

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Flexible X-ray detectors are relatively new entrant for radiography inspection, and for circumferential welds on pipes, in particular. Waygate Technologies is one of the first OEM to introduce an integrated solution using flexible detector. The solution offered by Waygate Technologies can be effectively used for inspecting circumferential welds on pipesfromfew inchesto 24 inches in diameter.

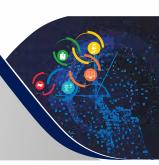
The paper 'Weld Inspection using X-ray flexible detector' discusses two aspects:(a) compelling reasons for the use of flexible detector for inspection of circumferential welds on pipe, (b) imaging stitching tool for providing a comprehensive view of the whole circumferential weld.

Three benefits of the flexible detectors are minimized distortion and un-sharpness in images, superior image resolution, and better sensitivity. These are definite advantages of flexible detectors for inspection of pipes. Image quality specified by different standards including EN176363-2 Class Bare met by the system that is offered. Innovative and aesthetic design of detector case allows easy strapping of detector on pipe, easy carrying and setting upby operator. Software powering the system improves productivity through automated acquisition and detector calibration, based on ASTM E2597. All these metrics are evaluated and compared with flat detectors in the paper.

Image stitching software toolsfor combining the images of different circumferential sectors of weld to a single high-resolution image are important for flexible panels use cases Image stitching can also provide a consolidated view of inspection data for the whole circumferential weld and can also help in ensuring that the weld around the whole circumference is 100% covered by inspection. Ideally, the acceptance criteria need to be applied for the whole circumferential weld and this can be enabled only using high fidelity image stitching method.

Keywords: Radiography, Flexible X-ray Detector, Image Stitching





#### On-field Testing of Pipes with Multiple Defects using a Smart FPGA-based Ultrasonic Guided Wave SHM System

**CP 40** 

**THE ABSTRACT** 

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This study presents a case study for a smart FPGA-based Structural Health Monitoring (SHM) system designed for analysis of defects in pipelines. The system was taken to an Oil & Gas PSU field testing facility for evaluation of pipe specimens. The defect detection was carried out using torsional ultrasonic guided wave modes with a ring of eight thickness-shear PZT transducers stuck on steel pipe of 12-inch diameter and 6.35 mm thickness. The custom-designed board, equipped with Xilinx Artix-7 FPGA and front-end electronics, facilitates signal excitation and data acquisition, and signal processing. The pipe contained several defects, with temperature variations across its surface due to outdoor installation. These defects of various sizes, were distributed circumferentially along different sections of the pipe. There were also circumferential welds, circumferential notches and distributed corrosion areas on the pipe. Data was collected alternately from four transducers while the other four were actuated, and the process was repeated by swapping the transmitter and receiver transducers. The transducers were excited using 50 kHz, 85 kHz, and 100 kHz frequencies to observe the impact of defects and corrosion. For high frequencies of 85 kHz, and 100 kHz, distributed corrosion area caused attenuation of wave packets for some receivers. The 85 kHz data showed higher amplitude and better packet separation than 50 kHz and 100 kHz, so further analysis was carried out using 85 kHz. Radar plots illustrated the impact of these defects on signal integrity. The system captured clear signals despite the high pipe temperature, highlighting its robustness and effectiveness in challenging conditions. This study emphasizes the broader industrial significance and potential for future scalability of such systems, taking into consideration challenges encountered in the field.

Keywords: Structural health monitoring, guided wave, torsional mode, pipeline, FPGA

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### Advanced Condition Monitoring of Studs and Bolts

**CP 41** 

THE ABSTRACT

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In service inspection or Condition monitoring of Studs and Bolts are major challenge in all the industries and very critical when it comes to safety of the employee or operators and environment. Any failure of these studs and bolds will lead to catastrophic, in order to avoid these kind of incident the asset owners are inspecting the studs and bolts periodically by visual inspection to ensure they are in torque and tightened. Apart from visual inspection in order to ensure the internal health of these studs and bolts one of the volumetric inspection approach is followed using ultrasonic testing.

In ultrasonic testing the sound waves are send through these studs and bolts from one end of the surface to opposite. By sending the sound waves the difference in energy level evaluated by conventional method to assess the condition of studs and bolts. Advanced solutions like phased array are used to visualize or built image like B-Scan, C-Scan and also increase the volume coverage, more probability of detection POD and faster. In this we will discuss results and the application of Total Focusing Method with Phased Array Ring array probe and 3D view of testing and its advantages to other conventional and normal Phased Array, Total Focus Method techniques of Studs and Bolts.

Keywords: Asset Integrity, Studs Bolts Inspection, TFM, PAUT, TFM 3D





#### Quality Assurance challenges during Manufacture of Taper Roller Bearings for High Temperature Applications

**CP 42** 

THE ABSTRACT

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An offset arm type machine, known as Transfer Arm (TA), is used for in-vessel handling of core subassemblies in nuclear facilities. The lower part of the TA has gripper assembly (GA) with its bearingsare partially immersed in hot liquid sodium. During the in-vessel handling process, an auto-orientation feature of fingers of GA is ensured with the help of a pair of taper roller bearings. As the bearings are immersed in hot liquid sodium during operation, conventional bearing steels are not suitable. Bearings hardfaced with NiCr-C alloys on the races and rollers are deployed for the purpose. Compared to NiCr-B, hardfacing with NiCr-C alloy results in higher hardness, galling resistance and reduced wear of the mating parts of the bearing.

The taper roller bearings consists of three parts: the cup, the cone and the rollers, all are made from austenitic SS with hardfacing on the contact surfaces. Quality assurance (QA) and inspection procedure during the fabrication of these parts includes the preparing of a detailed QA plan, specifyingtesting procedures, conducting material heat identifications, qualifying of hardfacing & heat treatment process, and performing final dimensional checks. In addition to adhering to stringent dimensional tolerances, it is crucial to ensure the required hardness, surface finish and soundness of the hardfaced interface to meet design specifications and codal requirements. By optimizing the manufacturing parameters, the hardness of the NiCr-C deposit was achieved within the range 50-55 HRc. The components were inspected by liquid penetrant examination for surface defects and also qualified by ultrasonic testing (UT) for subsurface defects. For carrying out UT, reference blocks simulating the geometry with flat bottom and side drilled holes were developed. The ultrasonic signals obtained on the reference block were also simulated using finite element analysis and a close correlation between the signals obtained by experimental and numerical simulation was observed. This paper consolidates the overall QA experiences encountered during the manufacturing and development trials of the hardfacing applied to the contact surfaces of taper roller bearings.

Keywords: QA, hardfacing, taper roller bearing, qualification, hardness, ultrasonic examination



## How AI, Image Processing, and Automation are offsetting NDT challenges

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**CP 43** 

THE ABSTRACT

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This session will explore advancements in Non-Destructive Testing (NDT) through the integration of image analytics, machine learning, and automation technologies. Focusing on use cases in welding, casting, x-ray quality, and other inspections areas, we will highlight how image enhancement and automation innovations improve the accuracy and efficiency of defect detection. Traditional methods of analyzing x-ray images, while effective are often time-consuming and depends on human experience/interpretation. Attendees will learn how cutting-edge machine learning and image analysis algorithms can analyze complex datasets to identify defects such as cracks, porosity, and misalignments, improving the overall quality control process.

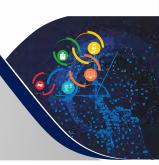
The event will also showcase automation improvements through the use of robotic arms and part-moving equipment, enabling factories and field operations to take dozens of x-ray images from various angles. By automating these processes, NDT workflows are significantly streamlined, leading to faster, more reliable, and repeatable results. Software-driven automation not only optimizes data acquisition but also integrates with robotic systems to enhance precision, reduce human error, and improve safety in industrial environments.

Additionally, the session will delve deeper into the development and training of AI models specifically designed and tailored for NDE applications. We will focus on real-world case studies from various industries such as aerospace, automotive and other manufacturing sector. Also highlight the key challenges and obstacles associated with implementing AI, including the need of high-quality annotated datasets, model interpretability and integration into existing workflow.

Participants will gain valuable insights into how these emerging technologies are reshaping NDT practices, driving efficiency, and ensuring superior product quality in various industries.

Keywords: NDT, AI, machine learning, image analytics





#### From Self-Sensing to Self-Awareness: Advancements in Monitoring Hydration and Microstructure in Conductive Cementitious Composites

**CP 45** 

THE ABSTRACT

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Current research on self-sensing cementitious materials primarily focuses on detecting the effects of external changes—such as strain, stress, damage, or temperature—after the material has hardened. While these materials exhibit self-sensing capabilities, allowing them to respond to external stimuli, they often lack a deeper understanding of their internal microstructural evolution during the early hydration phase. This distinction highlights that self-sensing involves reaction to external conditions, whereas selfawareness includes the ability to monitor and understand both internal states and external influences. This study aims to enhance the self-awareness of conductive cementitious materials by linking hydration monitoring with their electrical response from the onset of hydration. By tracking how hydration affects microstructural changes and electrical behavior, we can gaina comprehensive understanding of the material'sinternal condition, informing its responses to external factors. To achieve this, cement paste mixtures doped with carbon fibers were prepared with varying water-to-cement (w/c) ratios and admixtures. Electrodes were embedded to capture real-time, continuous electrical data from the onset of hydration. Four-probe resistivity measurements were performed by application of biphasic DC voltage over a three-day period, and these measurements were correlated with isothermal calorimetry data to track hydration product formation and microstructural evolution. The results reveal significant changes in resistivity measurements during early hydration, corresponding to key microstructural transformations such as pore refinement and the C-S-H gelformation. The rate of change in electrical resistivity also offersinsights into distinct hydration stages. Understanding these early transformations helps us interpret how Intrinsic Self-Sensing Concrete (ISSC) develops self-awareness, integrating knowledge of its internal hydration state with its responses to external stresses. This research underscores the importance of incorporating hydration-phase monitoring into self-sensing studies to capture the full rangeof material behavior. It also paves the way for developing ISSC designs that trackhydration, mechanical changes, and environmental conditions, ultimately leading to smarter and more reliable infrastructure.

**Keywords:** Self-Awareness, Intrinsic Self-Sensing Concrete (ISSC), Hydration Monitoring, Carbon Fibers, Microstructural Development, Electrical Response.



# Evaluation of Measurement Uncertainity of Silicon Elastomer Based Impression Technique For Quality Control Of Fine Defect Standards For NDT Sensor Calibration

**CP 46** 

THE ABSTRACT

Samadrita Chakraborty<sup>1\*</sup>, R.K. Gupta<sup>2</sup> and K.N. Karn<sup>3</sup>

NDT Methods such as Ultrasonic (UT) and Eddy Current (ECT) Methods are regularly used for Periodic In Service Inspection (ISI) of Pressure Tubes (PT) of Indian Pressurized Heavy Water Reactors for defect detection and wall thinning evaluation. NDT Sensors require Defect Standards of known dimensions for calibration.

Regulatory guidelinesfor ISI of Pressure Tubes of 220MWe PHWR require defect standards with dimensions  $6.35 \, \text{mm}$  (L) x  $0.15 \, \text{mm}$  (W) x  $0.066 \, \text{mm}$  (D) with close tolerances for NDT Sensor Calibration. These standards are machined on outer and inner surfaces of reference block having material composition and geometry similar to PTs. Efficacy of Testing and Interpretation of PTs using NDT Sensors is dependent on the calibration of the sensor. Hence, it is imperative to ensure proper calibration of sensors by measuring size of defect standards with high degree of accuracy.

Impression Technique is an indirect method capable of measuring dimensions of these defect standards. It comprises of two steps: i) Obtaining impression/replica of defect standard ii) Dimensional Measurement of impression obtained using High Magnification Digital Microscope. This measurement technique is portable and capable of enhancing machining productivity providing facility of online inspection of defect standards.

To ensure reliable quality control of defect standards produced, it is crucial to evaluate measurement uncertainity of Impression Technique. This paper presents several factors in the technique such as obtaining impression of defect standard, microscopic parameters, measurement parameters, operator skill, etcand their influence on measurement uncertainity. Evaluation of measurement uncertainity is performed at confidence level of 95%. It is concluded that measurement uncertainity using Impression Technique is well within required tolerance and is therefore anappropriate technique for online Quality Control of defect standards.

**Keywords:** Calibration, Quality Control, Measurement Uncertainity, NDT, Microscope, In-Service Inspection

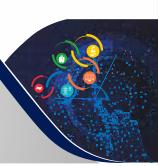
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# Comparative Evaluation of Fluoroscopy-Based and Flat-Panel Detector CT Systems: Performance and Application Insights

**CP 48** 

**THE ABSTRACT** 

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This paper presents a comparative study to evaluate the performance of an indigenously developed fluoroscopy-based cone beam computed tomography (CBCT) system against a flat-panel detector (FPD)-based CT system in X-ray-based radiation imaging for industrial applications. The primary motivation behind this comparison is to provide a cost-effective alternative to the widely used FPD systems, which are more expensive but offer higher image quality in terms of dynamic range and sensitivity. Fluoroscopic detectors, while being more economical and consuming less power, offer a lower dynamic range and sensitivity compared to their FPD counterparts. This makes the fluoroscopic system an appealing option for industrial CT applications where budget constraints and lower capital costs are significant factors.

The study quantifies CT image quality from both systems and provides useful insights that can assist stakeholders in making informed decisions when selecting a system for their specific industrial needs. The results of the comparative analysis show that the fluoroscopy-based system performs comparably to the FPD system in key performance metrics, such as image resolution, signal-to-noise ratio, and reconstruction accuracy. Despite the inherent limitations of the fluoroscopic detector—particularly in low-dose imaging environments and in applications requiring high contrast resolution—the system offers a viable alternative in many industrial contexts where high-end image quality may not be essential.

This research highlights the broader potential of fluoroscopy-based CBCT systems for non-destructive testing of industrial components and assemblies. It also proposes further studies to optimize real-time imaging capabilities and improve the overall performance of fluoroscopic systems, particularly in scenarios where image quality limitations could be addressed through software or system enhancements.

**Keywords:** CMOS detector, cone beam CT (CBCT), flat-panel CT system, non-destructive testing (NDT), cost-effective imaging, computed tomography (CT).



#### Development of a Fluoroscopy-Based Cone Beam CT System: Design and Implementation

**CP 49** 

THE ABSTRACT

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This paper presents the development of a fluoroscopy-based cone beam computed tomography (CBCT) system, aimed at providing a cost-effective alternative to traditional flat-panel-based CT systems. The system incorporates a customized acquisition software tailored for fluoroscopic X-ray imaging, which enables efficient data capture and enhances imaging performance. The acquisition software plays a critical role in ensuring that the data obtained from the fluoroscopic detector is accurately processed in real-time, while maintaining a balance between performance and cost efficiency. Additionally, a motion control system was meticulously designed to ensure precise mechanical movement of the imaging apparatus. This motion control system facilitates smooth and accurate data collection, ensuring consistent results across different scans.

To further enhance the operation of the system, prototype software was developed to manage the data acquisition process and control the mechanical manipulator. The software includes essential features such as real-time monitoring and adjustment of imaging parameters, enabling immediate responses to changes in the imaging environment. This adaptability ensures that imaging conditions can be fine-tuned to minimize errors during acquisition. A critical element of this development was the implementation of a synchronization protocol. This protocol coordinates the mechanical motion with data acquisition, ensuring that the system remains synchronized during the scanning process. By aligning the motion with the data collection, the protocol minimizes motion-related artifacts and optimizes the overall image quality.

The acquired data were reconstructed using the Feldkamp-Davis-Kress (FDK) algorithm, which is designed specifically for cone beam CT geometry. This reconstruction algorithm enables high-quality 3D volumetric imaging, which is essential for various industrial applications. The development emphasizes the potential of fluoroscopy-based CBCT systems as an effective solution for imaging in industrial settings, while addressing the need for lower costs and improved operational efficiency.

**Keywords:** CMOS detector, cone beam CT (CBCT), Feldkamp-Davis-Kress (FDK), motion control system, flat-panel CT system, non-destructive testing (NDT), cost-effective imaging, computed tomography (CT).





### Challenges of NDE in Nuclear Steam Generator Forgings

**CP 50** 

THE ABSTRACT

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This paper explains the challenges of NDE inNuclear Steam Generator Forging for Nuclear power plantis a key component in certain types of nuclear reactors, particularly in Pressurized Water Reactors (PWRs). It serves as a heat exchanger that transfers heat from the reactor's primary coolant system to a secondary system, producing steam that drives the turbine-generator to produce electricity.

Non-Destructive Evaluation (NDE) of nuclear power forging components presents several challenges, given the critical nature of these components to ensure safety and reliability in nuclear power plants. These challenges include:

Key challenges include the material complexity of large and thick sections where grain structure variations hinder the detection of small, deep-seated defects.

Achieving high sensitivity and accuracy is essential, but difficult, especially when regulatory standards demand near-complete inspection coverage. Time-consuming inspections, complex geometries, and limited accessibility further complicate the process.

Additionally, standardization and qualification of techniques are resource-intensive, and the risk of false positives or negatives can lead to flawed decision-making. Nuclear industries are highly regulated, and NDE procedures must meet stringent standards (e.g., ASME Section V and stringent customer specifications). Ensuring compliance while maintaining efficiency can be a challenge.

Addressing these challenges requires ongoing research and development in NDE techniques, training of skilled operators, and a comprehensive approach to ensure nuclear power forging components maintain their structural integrity throughout their service life.



## Design of a Wireless Antenna Sensor with Resonator Array for Real-Time Structural Health Monitoring

**CP 51** 

THE ABSTRACT

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In this work, anovel wireless sensor is designed based on a microstrip antenna integrated with an array of resonators, specifically developed for Structural Health Monitoring (SHM). The array of resonators functions as a sensing element that is highly sensitive to structural anomalies such as surface cracks, material degradation, or damage in both metallic and composite structures. By attaching the resonator array to a wideband antenna, the system can detect and transmit real-time structural health data over a broad frequency spectrum, ensuring efficient and accurate monitoring even in complex operational environments. The integration of the resonator array with the microstrip antenna provides the sensor with the ability to respond dynamically to changes in the structure, operating as a band-stop or band-pass filter depending on the state of the structure. The principle of surface crack detection is rooted in perturbation theory, wherein the resonant frequencies of the sensor are altered by the presence of surface cracks, causing shifts that can be accurately detected and analyzed. This frequency shift is key to the sensor's ability to discern between damaged and undamaged conditions. The sensor's design is further validated through rigorous simulations and equivalent circuit modeling, which demonstrate the accuracy and consistency of the proposed approach. This wireless SHM sensor has significant potential for monitoring and maintaining the structural integrity of critical infrastructure systems such as aircraft, bridges, pipelines, wind turbines, and nuclear power plants. Its capacity for real-time, remote monitoring reduces the need for frequent manual inspections, offering a more efficient and cost-effective approach to infrastructure management.

Keywords: SHM, Resonators, Microstrip Antenna, Sensor array, Perturbation Theory, surface Cracks.





#### GPU-Accelerated Implementation of Rotated Vector Sum Algorithm to Mitigate Intensity Fading in Distributed Acoustic Sensing

**CP 52** 

THE ABSTRACT

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Distributed acoustic sensing (DAS) is attracting tremendous interest recently for a variety of applications including perimeter sensing, intrusion monitoring, leak detection, and industrial process monitoring. DAS utilizes Rayleigh backscattering in optical fibers to achieve unprecedented long-range monitoring over hundreds of kilometers with spatial resolution of a few meters. However, intensity fading due to interference between the Rayleigh backscattered wave components leads to information loss, compromising sensing accuracy and reliability. In this study, we present a GPU-accelerated implementation of the Rotated Vector Sum (RVS) algorithm to address the challenges due to fading points in DAS.

Our approach optimizes the RVS algorithm for GPU computation, focusing on cost-effective sensing without specialized hardware. The enhanced RVS method processes three lobes of the beat signal, effectively mitigating fading while preserving crucial acoustic information. By leveraging GPU parallelization, we extract and analyze these lobes simultaneously, significantly reducing computation time and improving overall system performance. The experimental setup involved a rectangular light pulse of width 200 ns, 5-10km long optic fiber, and perturbations ranging 10 - 150 Hz. Our initial processing involved two filter banks for signal smoothing, which has now been superseded by the GPU-accelerated RVS algorithm. This clever coding strategy not only addresses the fading issue but also enhances computational efficiency.

Results demonstrate a two-fold reduction in processing time compared to our previous two-filter method. The GPU-accelerated RVS algorithm successfully mitigates fading points, enhancing the reliability and efficiency of acoustic sensing over extensive distances. These advancements enable more robust monitoring in applications such as border security, pipeline surveillance, and infrastructure monitoring.

In summary, this research contributes a computationally efficient solution for fading mitigation in DAS, enabling rapid inference and robust performance without incurring high hardware costs. Our findings highlight the potential of GPU computation in DAS signal processing, paving the way for real-time, high-fidelity acoustic sensing across vast distances.

**Keywords:** Distributed Acoustic Sensing, Optical Fiber Sensors, Intrusion Monitoring, Leak Monitoring, Industrial Process Monitoring



# Acoustic Emission Data Filtering and Analysis Using Simple and Complex Approaches for Different Materials

**CP 53** 

THE ABSTRACT

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Structural health monitoring (SHM) involves continuously observing a structure's condition to detect damage or deterioration. There are two main SHM techniques: active SHM, where an external stimulus like vibrations or waves is applied to assess structural integrity, and passive SHM, such as Acoustic Emission (AE), which detects energy released during material damage (e.g., fracture, cracking, delamination). The passive SHM approach is particularly useful when detecting various damage mechanisms, and continuous health monitoring of a given system is a prime goal. However, AE generates a huge volume of data, especially in the case of composites, as we try to capture high-frequency content, which requires a high sampling rate. Therefore, it is important to eliminate noisy data and denoise accepted data. The present study considersacoustic emission data from two materials: concrete and carbonfiber-reinforced polymer (CFRP). A concrete cylinder was subjected to axial compression, and the CFRP coupon was subjected to uniaxial tension, both monitored using AE sensors. First, the unwanted waveform data is eliminated, and further, accepted data is denoised using sequential denoising. As a part of data analysis, two approaches are followed: a simple approach using extracted features-based analysis and a second complex approach using AE waveform analysis. A simple approach involves the use of typical AE cumulative hits, whereas complex analysis considers second-order Rényi entropy. A comparison of results from both approaches reveals the effectiveness of simple feature-based extraction in data analysis. The adopted filtering methodology was also effective in filtering out useless data and denoising accepted data.

Keywords: Sequential Denoising, Acoustic Emission (AE), Entropy, Data filtering, Composites, Concrete.





# NDE Tools for In-situ Measurement of the Effectiveness of the Shot Peening for Improvement of Steam Oxidation Resistance of Austenitic Stainless Steel Boiler Tubes

**CP 54** 

THE ABSTRACT

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NTPC Energy Technology Research Alliance (NETRA), Greater NOIDA-201306,

It is known that in the austenitic stainless steel boiler tubes (\$\$S347 or similar grade), there is higher tendency of exfoliations of internal oxides, which may subsequently accumulate at lower bend of the tube coil causing blockage in steam flow and forced outage of the plant. Shot peening of internal surface of these tubes is an effective technique for reducing the exfoliation from these tubes. NTPC has started shot peening of these austenitic tubes, where they have been recently installed, while changing the specification to include this process for this type of boiler tubes for new procurement.

Presently, the adherence to and effectiveness of the shot peening procedure (executed by external agency for tubes already installed) is being ensured through checks like visual examination, shot peening intensity assessment though an Almen Strip in the field and checks in the lab on cut samples from tube inlet, bend and outlet. Presently, there is lack of NDE tools for quick checking/screening of all the tested tubes from large number of tubes (normally  $900\sim1000$ ) being shot peened in in-situ condition to distinguish efficacy of shot peening in the tubes or identification of tubes not undergone shot peening.

The literature shows that shot peening creates uniform cold-worked layer along the tube ID and it has a profound effect on oxidation resistance. Shot peening introduces compressive residual stress through plastic deformation and work hardening of the underlying material by increasing the dislocation density (i.e. forming slip bands and dislocation piles) and material constraint. Shot peening also modifies the ID of austenitic stainless steel (SS 347/S304) superheater tubes. It is reported that both improves the overall oxidation resistance to steam. Decreasing the oxidation rate directly impacts the exfoliation rate. Most of the improved oxidation resistance can be attributed to the presence of a spinel oxide layer combined with a continuous chromia layer formed near the steam-touched surfaces. The presence of a continuous chromia layer greatly reduces the outward diffusion of iron and minimizes the formation of iron-based scales that exfoliate.

Although destructive testing is reliable for estimation of shot peening efficacy, an NDE tool based on magneto-strictive effect has been explored to measure the shot peening efficacy at site. The shot peening affects the parameters and signal strength of the magnetostrictive sensor for tubes having shot peened surface at ID. The paper also presents case study with measurement at site.

Keywords: Magnetostrictive Sensor, SS347 Austenitic Stainless Steel, Shot Peening

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## End Plug Weld Evaluation of FBTR Fuel Pins by Computed Radiography

**CP 55** 

THE ABSTRACT

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End plug weld evaluation is an important quality control steps during Fast Breeder Test Reactor (FBTR) fuel pin fabrication at RMD, BARC [1]. The End plug weld evaluation is routinely being carried out using conventional film-based X-ray radiography method [2]. Although film radiography has been a reliable imaging method with good basic spatial resolution it poses many limitations such as it necessitates a dedicated space with controlled lighting conditions, prolonged exposure and film processing is more time consuming and involves uses of harmful chemicals. To get rid of these difficulties film free method like computed radiography with image plate is being employed in medical as well as industrial radiography. This paper presents the feasibility study of end plug weld evaluation of FBTR fuel pins by computed radiography. The end plug welds of nuclear fuel pins is very thin weld joints of total thickness 5.1 mm. The weld qualification criteria require minimum 2% sensitivity on radiographs [3]. 2% sensitivity of 5.1mm thickness requires discernibility of 100µm wire type Image Quality Indicator (IQI) on film as well as on digital radiograph. The initial trials of weld evaluation with computed radiography showed the capability of achieving 100µm contrast sensitivity. Moreover, the basic spatial resolution and normalized signal to noise ratio (SNRN) were also evaluated in the obtained image to check the image quality of CR system [4]. Further, to check the detect-ability of flaws, various pins with weld defects were evaluated and it was observed that all types of defects could be revealed easily with high contrast and sharpness.

**Keywords:** Computed radiography; contrast sensitivity; IQI; Basic spatial resolution. References

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#### NDE 4.0 & QC aspects in Thermal Power Generation-Present scenario and Way forward

**CP 56** 

THE ABSTRACT

Vinay D. Gaddu

This presentation discussed the journey of Indian Power Thermal generation sector towards achieving NDE 4.0. The achievements thus far and the impediments in the journey are discussed. The presentation outlines the importance of timely and thorough quality control for ensuring the trouble free life of power plant equipment. The presentation discussed various topics and case studies to highlight specific issues.

One of the main challenges faced in proper implementation of QC and NDE 4.0 is the present mentality of power generating entities to minimize cost of NDE and inspection. This is happening mainly due to unawareness of importance of NDE AND QC in improving plant reliability. National institutions and standards have a definite role to play in this. The power generation stations will have to move beyond the lowest cost bidder to highest quality bidder. Once this happens, many things will fall into place. Also , organizations will have to invest in trials and new startups for research and not just look at ready -to- use products.

The need for moving beyond NDE and the use of big data analytics to resolve recurring problems affecting plant availability is discussed in the beginning of the presentation. The presentation then highlights the importance of doing timely borescope inspection during the construction stages to prevent repeated boiler tube failures later during service. The limitations of applications of robotics during a boiler tube failure and also during planned outages is discussed. The importance of calibration in PAUT and the advantages of microscopy over portable oxide meters is discussed.

Presently for turbine rotor WFMT we are using cable wrap method. However, this is time consuming and error prone. The need for a more comprehensive testing and alternate method of magnetization is being discussed.

To conclude, considering the Indian Power generation scenario, the applications of AI/VI/ Digital Twins, Robotics will require a fresh outlook. The present dependance of manual testing, interpretation and "experience" must be done away with. This paper prefers to look at the future in a positive way so that this will indeed bring the change desired: sooner than later.



## Optimised detection and sizing of pipe corrosion at supports using guided wave technology.

**CP 57** 

THE ABSTRACT

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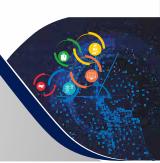
Corrosion under pipe supports (CUPS) represents one of the most prevalent pipe defects encountered across oil, gas, and petrochemical facilities, posing serious risks of pipeline structural failure and ultimately product containment loss. Despite being external in nature, locating CUPS remains a formidable task due to the sheer number of pipe supports per pipeline, often numbering in the hundreds. Conducting visual testing for each support proves impractical, particularly when pipes are elevated on racks or insulated. Addressing this challenge, this presentation introduces an optimized methodology for CUPS detection and sizing.

Firstly, LRUT or guided wave testing (GWT) using the fundamental Torsional guided wave mode is used to quickly and reliably detect the position of CUPS damage. This approach integrates a broadband guided wave screening technique which complies to ISO 18211, ASTM E2775-16 and BS 9690, ensuring reliable detection of CUPS over extensive pipe lengths. Secondly, an accurate guided wave scanning technique is employed for precise quantification of the remaining pipe wall thickness at corrosion sites. This guided wave scanning employs a quantitative short range (QSR) frequency-based guided wave analysis method to quantitatively and accurately size the pipe remaining wall thickness.

The efficacy of this method is demonstrated through inspection results obtained from an 8-inch pipeline situated on a pipe rack within a petrochemical complex, identified as a critical asset by its owner. These results showcase the early detection of several CUPS defects and provide insights into the extent of damage in terms of remaining pipe wall thickness. Through the synergistic utilization of guided wave screening and scanning techniques, this methodology offers a robust solution for enhancing CUPS detection and facilitating proactive maintenance strategies within industrial facilities.

**Keywords:** Guided wave testing, pipeline, corrosion at pipe supports, LRUT





#### Leveraging Digital Solutions to Optimise Asset Integrity Management

**CP 58** 

THE ABSTRACT

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In today's volatile geopolitical landscape, refineries face increased challenges in Asset Integrity Management (AIM) due to the processing of "opportunity crudes"-crudes that are less consistent in composition and can introduce/ pose new risks to asset integrity. Advanced digital solutions are becoming crucial in addressing these challenges & are being applied as:

- Predictive Analytics: Effective monitoring of Integrity Operating Windows (IOW).
- Real-Time Data Acquisition: Monitoring real time thickness of critical piping circuits by installing non-intrusive thickness / corrosion monitoring sensors.

#### **Predictive Analytics:**

Predictive analysis by monitoring leading indicators e.g. effective monitoring of IOW in process plants of refinery helps in detecting early signs of corrosion, potential damages, failures or other potential issues. Timely addressing the corrosion / integrity related issues prevents minor problems from escalating into major failures.

#### **Real-Time Data Acquisition:**

Corrosion in critical piping circuits and its monitoring is a challenge that the industry faces as the units are expected to have increased run length. Processing of variety of crude makes it difficult to keep a track of the healthiness of the equipment and associated piping circuits as the corrosion and associated damages do not behave in a defined pattern. Online wireless thickness monitoring tool gives the plant inspector the true picture of the corrosion happening in the piping circuits.

By leveraging these advanced digital solutions, we have enhanced Asset Integrity Management practices, which effectively manage the risks associated with opportunity crudes, and ensure safe and efficient operations despite the uncertainties of the current geopolitical climate.

Keywords: Digital Solutions, Corrosion monitoring, Asset Integrity Management.



## Qualification of Thin Walled Nickel Tubes For Hydrogen Detection Using Helium Leak Testing.

**CP 59** 

THE ABSTRACT

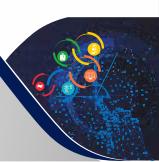
\*S P Manivannan, J Mohan, M V Kuppusamy, K V Rajkumar ,Vidya Sundararajan Quality Assurance Division, Indira Gandhi Centre for Atomic Research, DAE, Kalpakkam – 603102 \*spmani@igcar.gov.in

Detection of presence of hydrogen in Argon cover gas will help in early identification of steam leak in Sodium, so as to avoid any catastrophic failure. Hydrogen in argon Detector (HAD) is safety related device used in argon gas area of fast reactor to detect Hydrogen in PPB levels. Nickel diffuser comes as a part of part of HAD is chosen due to high diffusion for Hydrogen and also compatibility with Sodium. Nickel diffuser assembly is made up of 6 nos of thin walled Nickel tubes of size OD 2.5 mm and thickness of 0.25 mm, bent to U shape and lip seal welded with splitted bottom flange. The top header flange was split into two segment using EDM cutting wire process for easy of assembling around the central pipe. The nickel tubes welded to the top header flange were attached to central pipe using 100 micron thick and 5 mm width SS straps shot spot welded to keep them intact with central pipe. Stringent quality assurance practices are adopted during every stage of fabrication of Nickel diffuser assembly for HAD. Helium leak testing (HLT) is used to ascertain the leakage rate of Nickel diffuser assembly. Allowable Leakage rate of assembly is <1.1X10 -9mbar.l/sec. Vacuum technique as per ASME Section V Article 10 was used for helium leak testing of the assembly.HLT is performed in each stage right from as-received tubes, U bent tubes, lip seal welds and assembly as a whole by taking into account thin walled and compact assembly. This paper mainly addresses the development, validation and field implementation of HLT for qualification of Nickel diffuser assembly.

**Key words:** Nickel diffuser, Sodium, Helium leak testing, Structural integrity.

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### High Resolution Lock-in Thermography Using Structural IR-Excitation

**CP 61** 

THE ABSTRACT

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The naturally diffusive heat flow in solids often results in differences in surface temperatures. Active thermography (AT) exploits such differences to gain information on the internal structure, morphology, or geometry of technical components or biological specimens. In contrast to sound and light waves, thermal waves are lossy; consequently, it is difficult to interpret measured 2D temperature fields. Most AT evaluation methods are based on 1D approaches, and measured 3D heat fluxes are frequently not considered, which is why edges, small features, or gradients are oftenblurred. Herein, we present a method for reducing the local temperature gradients at feature areasand minimizing the induced lateral heat flux in optical lock-in thermography (LT) measurements through spatial- and temporal-structured heating. The vanishing lateral gradients convert the problem into a 1D problem, which can be adequately solved by the LT approach.

The simulation and experiments show that by feeding the measured temperature distribution back into an IR beamer, it is possible to completely homogenize the thermogram. In doing so, the variables intensity, phase and offset are varied for each pixel of the 1280 x 1024 beamer array. The contrast image, which is now slowly disappearing in the IR camera with each further iteration, now appears in a much sharper image in the IR beamer. Due to the fact that the IR beamer has actually physically compensated for the lateral heat flows to a large extent, the smearing caused by lateral heat flows naturally also disappears. The proposed compensation method also bypass the blind frequency of LT and make the inspection largely independent of the excitation frequency. Furthermore, the edge sharpness and separability of features are improved, ultimately improving the feature-detection efficiency.



#### HeXRayNet: A foundation model for Automatic Defect Recognition in Digital Radiographic Images of Castings

**CP 62** 

THE ABSTRACT

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Non Destructive Testing and Evaluation (NDT and NDE) is a critical part of many industrial manufacturing and inspection processes, but its reliance on human operators for quality makes it time and effort consuming, expensive, and harder to scale. We have built a suite of deep learning based models to create solutions that can provide assistance to human operators in defect recognition in digital radiographic images of castings in an industrial setting.

Defects in castings (like gas holes, shrinkage sponge, etc) images can often be hard to detect due to their very small sizes. Real world conditions, like dead pixels in scanners, or irrelevant material (like shavings) left on the scanning bed add to the challenge as well. A bigger challenge is to generalise solutions across different tasks and machines.

While deep learning has seen fast progress in general image processing tasks owing to transfer learning from models trained on the Imagenet dataset (of millions of generic images), similar foundation dataset and models have been missing for x-ray images. Using a model trained on Imagenet for transfer learning for x-ray images is highly inefficient, as even the low level features learnt from these images look very different.

To help address the lack of large high quality datasets for defect recognition tasks in high energy digital radiographic images, we built a foundation model, HeXRayNet, to serve as the backbone for detection and segmentation tasks using self-supervised learning. We combined contrastive learning with proprietary image pre-processing techniques to improve our baseline model performance from 78.4% (transfer learning and fine-tuning with Imagenet models) to 86.2% (using HeXRayNet) across a range of tasks, while reducing the training time by more than 20%.

We expect HeXRayNet to make it easy for everyone to fine-tune and adapt deep learning models for automated defect recognition to their own workflows and tasks.

**Keywords:** NDE, NDT, Castings, Deep Learning, Computer Vision, Defect Recognition, Self-Supervised Learning, Contrastive Learning, ADR





# Implementation and Operational Safety of a High-Energy Radiation Application Facility for Non-Destructive Testing

**CP 63** 

THE ABSTRACT

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This paper presents our experience in operationalizing a new high-energy (7 MeV) betatron acceleratorbased X-ray radiography and Co 60 based gamma ray radiography facility designed for industrial radiography and computed tomography of components with up to 200 mm steel-equivalent thickness. It covers operational characteristics and radiation safety measures for efficient, regulated, and safe use of the X and gamma ray generator. The system produces X-rays at a maximum energy of 7 MeV, capable of penetrating thick castings, composites, forgings, and welds in steel, copper, aluminum, and concrete. It can also inspect high-density materials like lead, tungsten, uranium, and nuclear components such as specialized valves and thick-walled vessels. This facility is important for research, development, quality control, and assurance of nuclear components in BARC. Shielding requirements of the enclosure housing the electromagnetic radiation sources have to be evaluated during the design stage using theoretical calculations. Later they have to be duly verified after installation of the equipment for shielding adequacy with a radiation safety survey. The high-energy X-rays allow for deeper inspection without damaging materials, ensuring structural integrity and compliance. Betatron-based X-ray generators are valued for their transportability, making them ideal for on-site industrial non-destructive testing (NDT). Compact and mobile, they can be easily deployed in remote or challenging environments, offering high-energy X-rays for verification of shielding adequacy with radiometric studies or qualification of joints, forgings and/or castings reducing overall lead time. The paper also discusses trail studies carried out on computed radiography image plates using x-rays as well as Co60 industrial gamma ray exposure device. The facility is currently undergoing regulatory approval from the BARC Safety Council (BSC) for its regular operation.

**Keywords:** Accelerator based X rays, betatron, radiography testing, computed tomography, radiation shielding, radiography enclosure.



### Eddy current Thermography Technique for He cooled Plasma Facing Components

**CP 64** 

THE ABSTRACT

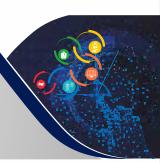
Kedar Bhope<sup>1</sup>, Mayur Mehta<sup>1</sup>,Alpesh Patel<sup>1</sup>, Shailesh Kanpara<sup>1</sup>, Samir Khirwadkar<sup>1,2</sup>, Sunil Belsare<sup>1</sup>, Tusharkumar Patel 1, Prakash Mokariya<sup>1</sup> <sup>1</sup>Institute for Plasma Research, Bhat, Gandhinagar-382428, India <sup>2</sup>Homi Bhabha National Institute, Anushaktinagar, Mumbai-400094, India Corresponding Author: kedar@ipr.res.in

The helium (He)-cooled plasma facing components (PFCs) is new divertor cooling concept proposed for future fusion reactors. The cooling of the divertor PFCs subjected to high heat fluxes is realized by helium jet impingement concept. Helium at high pressure (~10 MPa) is forced through small holes to accelerate and impinging on the inner surface of a thimble-like cap, which is brazed with the plasma-facing tungsten tile, and it flows out of the finger. He-cooled PFCs design is to withstand the heat load in range of 5 to 10MW/m2. He-cooled PFCs is manufactured using brazing process which may incorporate defects at curved joint interface between thimble and tungsten tile. One of the quality control steps during fabrication of these components is the Eddy Current Thermography (ECT) of bonded region between similar metal joints.

This work focuses on ECT to assess the quality of curved tungsten-to-tungsten joints of He-cooled type mock-ups fabricated at IPR Labs, India. An ECT technique has been developed at IPR to assess the integrity of curved tungsten to tungsten joints. By using a specially designed copper coil, eddy current is used to generate heat in the components. The surface temperature profiles were recorded using an infrared camera. Thermal profile analysis will provide detailed information about the bonded area. Additionally, Obtained Thermal profiles are compared with ultrasonic results for the validation. A curved tungsten to tungsten interface joints were investigated successfully in divertor PFCs. Thermal profile images realize the location of defects present at joint interface and its effect on heat transfer which helps effectively assess the manufacturing quality of He-cooled divertor PFC. A description of the experimental methodology, validation and test results is presented in the paper.

Keywords: He-cooled PFCs, Eddy Current Thermography, Thermal profile, Divertor.





### UT is UT: Understanding Advanced Ultrasonic Technologies and How They Compare to Each Others.

**CP 65** 

THE ABSTRACT

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In recent years, there has been significant advancements in portable ultrasonic techniques such as the introduction of newer data collection methods like full matrix capture (FMC) and plane wave imaging (PWI), as well as advanced data processing algorithms like the total focusing method (TFM) and phase coherence imaging (PCI). These techniques are gaining recognition within the industry for their enhanced imaging and sizing capabilities over the traditional Ultrasonic Testing (UT) and Phased Array Ultrasonic Testing (PAUT). However, like any ultrasonic testing (UT) method, these advanced inspection techniques are governed by the same fundamental laws of physics, and their performance relies on the input parameters used. The accuracy of results can also be affected by the properties of test component such as material composition, geometry/access etc. From physical probe characteristics to the choice wavesets for image reconstruction, a vast array of variables must be optimized to extract the best results. Therefore, a thorough understanding of the variables and operational limitations associated with these methods is essential for using them in practical applications. This presentation aims to provide a comprehensive comparison and analysis of the key parameters involved and their effect on imaging and sizing capabilities when compared to traditional focused phased array ultrasonic inspection.

**Keywords:** Phased Array Ultrasonic testing, Full Matric Capture, Total focusing Method, Phase Coherence Imaging, Plane Wave Imaging, Signal to Noise Ratio

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#### Understanding the Temperature Effects on PZT-Based Embeddable Transducers

**CP 66** 

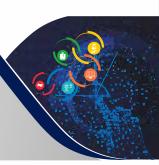
THE ABSTRACT

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Among all the sensing technologies, the development of embeddable transducers for the continuous health monitoring of civil engineering structures has gained significant importance over the past decade. The majority of the developed embeddable transducers utilized PZT (Lead-Zirconate-Titanate) coupled with structures, due to its higher coupling factor and cost-effectiveness. However, the precise interpretation of the transducer data gets more intricate since these transducers exhibit greater sensitivity to the varying temperature due to their inherent properties. Temperature fluctuations have the potential to taint the structural health monitoring (SHM) system, producing erroneous signals regarding the structural health. To comprehend the effects of temperature on the embeddable PZT transducers, in this study, a temperature characterization of PZT-5A type patches is carried out forstepwise increment in temperature ranging from 25 to 150 degrees Celsius. The thermal effects of PZT-5A patches are characterized by the electrical impedance response of the material, spanning from 20 kHz to 150 kHz. The analytical impedance response of the PZT at ambient temperature is calibrated using an experimentally determined impedance response. The variation of electrical impedance over several temperature ranges is evaluated and the changes in electrical and mechanical properties of the PZT at various temperatures are quantified by minimizing the error between experimental and analytical responses through optimization. The variations in the impedance response were also assessed utilizing root mean square deviation (RMSD) and the shifts in resonant frequency and resonant amplitude. This research facilitates the advancement of more resilient PZT-based embedded sensors that can autonomously mitigate the temperature dependence.

**Keywords:** Electrical impedance, PZT sensors, Temperature effects.





# Evaluating 3D-Printed Concrete Beams With Weak Interfaces Under Bending: Insights Into Crack Dynamics From Acoustic Emission(ae) And Digital Image Correlation (dic)

**CP 67** 

THE ABSTRACT

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3D concrete printing is an emerging technology in the construction industry, offering potential for lean and rapid construction. This layer-by-layer deposition process, however, can result in the formation of weak interfaces between layers, primarily due to factors such as the time gap between successive depositions. Characterizing these weak interfaces is crucial for understanding the mechanical behavior of additively manufactured structures. This paper investigates the behavior of weak interfaces in 3D-printed plain concrete beams, subjected to tensile and compressive stress during three-point bending tests. The experimental setup was designed is such that the weak interfacesubject to tensile and compressive stresses. The load was applied in displacement control, using the Crack Mouth Opening Displacement (CMOD) method. Acoustic Emissions (AE) were monitored throughout the loading process to capture crack dynamics, while Digital Image Correlation (DIC) was employed to obtain detailed strain distributions and crack patterns on the surface of the 3D printed concrete beam. The study focuses on correlating AE data with crack characteristics observed through DIC, emphasizing the response of weak interfaces under tensile and compressive stress. From DIC analysis, it was observed that the crack is propagating along the length of beam at the weak interface. High-frequency AE signals during crack propagation indicated the location and delamination of printed layers at the weak interface. The findings suggest that weak interfaces in the tension zone make the crack propagate along the interface, leading to delamination of layers. In contrast, weak interfaces in the compression zone exhibit minimal influence, with the beam demonstrating near-composite behavior. These results provide valuable insights for optimizing the design of 3D-printed concrete structures, accounting for the differential impact of weak interfaces under tensile and compressive loading conditions.

Keywords: 3D concrete printing; Weak interface; Damage; Fracture; Acoustic emission; DIC.





**CP 68** 

THE ABSTRACT

### Deep learning model for pipeline feature detection using MFL signal

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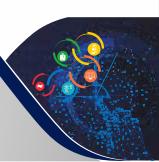
Integrity management of cross-country buried carbon steel (CS) oil pipelines is a formidable challenge for pipeline operators. A popular method for non-destructive evaluation (NDE) of such pipelines is Magnetic Flux Leakage (MFL). The technique involves magnetizing a pipe section to near saturation and sensing the leakage flux using an array of circumferentially disposed Hall-effect sensors, mounted on an inline inspection (ILI) tool, commonly known as Instrumented Pipeline Inspection Gauge (IPIG). This ILI tool moves through the entire pipe length, recording the sensor data in its internal storage. The data is downloaded after inspection run and analyzed offline to determine essential parameters for health assessment of the pipelines. These include metal-loss (corrosion) defects as well as identification and classification of pipeline features (welds, sleeves, flanges, valves, tees, markers etc.). Classical approach to this data analysis is to convert the array of sensor data into images and use customized image/signal processing algorithms along with different empirical models for detection of metal-loss defects and various pipe features. These models depend on various parameters like pipeline diameter, material, magnetization level etc.

To explore a generic scheme to detect and classify pipeline features independent of pipe sizes and IPIG tool, the paper proposes an alternate approach by using a pre-trained deep learning model. The model is based on YOLOv8 (You Only Look Once), which is a customization of Cross-Stage Partial Darknet53 (CSPDarknet53). It is trained on large annotated datasets (e.g., COCO) and can perform real-time object detection due to its streamlined architecture. Dataset to train the model is sourced from a) 280km of 12" NB CS pipeline from tools having different magnetic configurations and b) 224km of 14" NB CS pipelineinspection. Images were generated by combining sensor data, with pixel intensity representing sensor output. These images are labelled with pipeline features based on field inspection reports.

The YOLOv8 nano model is trained on a dataset consisting of 350,000 images for training, and 75,000 images each for validation and testing. The model is tuned to enhance detection accuracy by controlling learning rate, input image size and augmentation. Image augmentation was done by color variation (hue and saturation adjustments) to better generalize the model across pipeline of different sizes. The trained model achieved a high mean Average Precision (mAP50) of 0.94, (mAP50-95) of 0.9 and F1 Score of 0.91, demonstrating the effectiveness of the proposed scheme.

**Keywords:** Magnetic Flux Leakage (MFL), Instrumented Pipeline Inspection Gauge, YOLOv8, Pipeline Feature Detection, Deep Learning





# Comparative study on over 150m of welded joints using established (PA/TOFD) and emerging (PCI/TFM) ultrasonic imaging methods

**CP 69** 

THE ABSTRACT

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- (1) Evident Europe
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- (3) Evident Canada

Instantaneous Phase Coherence Imaging (IPCI) or, simply Phase Coherence Imaging (PCI) is a recent NDT technique developed for imaging of small UT indications like crack tips, inclusions or porosities in the welds. Derived from the wider used technique of Total Focusing Method (TFM) and Full Matrix Capture (FMC), PCI relies on phase information rather than amplitude to enhance diffracted signals coming from discontinuities in the area of interest. In (1) the authors have already explained the benefits of PCI over more traditional techniques like Time Of Flight Diffraction (TOFD) on theoretical models and laboratory data. The current study aims to extend the previous work on PCI by applying it to a larger number of real-life pipeline construction welds.

A 48in pipeline construction project represented a good opportunity to assess the benefits of Phase Coherence in a real-life project. One of the qualified and approved methods for the inspection of the 48in OD pipeline welds is Phased Array Ultrasound (PAUT) in conjunction with Time Of Flight Diffraction (TOFD). The current study will include the analysis of more than 150m ofwelded joints during the construction phase of the pipeline. The data files will be acquired using the qualified PA/TOFDmethod, while additional files will be generated on the same welds by using the TFM/PCI techniques.

The analysis of the results will consider several parameters like acquisition time, accuracy of detection and sizing of indications in the TFM/PCI data with respect to the qualified PA/TOFD method. This presentation aims to discuss the findings.

#### References

(1) Gauthier, B.; Painchaud-April, G.; Le Duff, A.; Bélanger, P. Towards an Alternative to Time of Flight Diffraction Using Instantaneous Phase Coherence Imaging for Characterization of Crack-Like Defects. Sensors 2021, 21,730. https://doi.org/10.3390/s21030730



### Progressive Web App for AWS D1.1 UT Environment

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CP 71
THE ABSTRACT

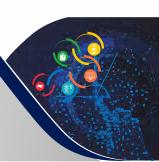
AWS D1.1 is a well-known code for structural steel groove welds in infrastructure projects. Given the current surge in infrastructure projects in India, there is a pressing need for rapid processing of NDT results to ensure on-time project delivery. For detecting internal weld defects, manual contact A-scan Ultrasonic NDT is favoured due to its affordability and safety. While 'D' rating calculations as per AWS D1.1 are often available on various UFDs for quick evaluation, the processes of data recording, storing, and report printing remain time-consuming.

NDE4.0 is the keyword in industry today. The author of this work has developed a cloud-based application, validated over two years on a major project by a renowned Indian projects company, which can be operated via any smartphone. Data related to the worksite, job details, shifts, equipment, probes, blocks, etc., is uploaded to the cloud database, making it accessible as dropdown options on the app. The UT operator can log test results through structured input forms, with data automatically archived on the cloud with a timestamp.

The application features include 'D' rating calculation, automatic interpretation of defect location and depth in the weld cross section, and remote printing of final reports, with the option to select multiple joints in one report. This tool has significantly reduced human error and effort, resulting in considerable savings in the cost and time of processing test observations. The cloud-based cumulative database can be accessed by authorized personnel anytime, anywhere. Lost printed reports can be easily verified for test history and re-issued. Traceability to operators, equipment, calibration, etc., is swift and precise, aiding in effective non-conformance root cause analysis.

**Keywords:** Ultrasonic, AWSD1.1, 'D' Rating, NDE4.0, Smartphone App, PWA, Automatic reporting, defect location, traceability.





# Optimization of Film-to-X-ray Source Distance for Enhanced Subsurface Indication Detection in Multi-Layered Specimens using Radiography

**CP 72** 

THE ABSTRACT

T. Antony Prabhu, G.Kamesh Guru, Surya Prakash Singh, P. Padmanabhanand D.P Sudhakar ISRO Propulsion Complex ,IPRC, Mahendragiri ,India antonyprabhu15@gmail.com

Non-destructive testing (NDT) using X-ray radiography is essential for detecting subsurface indications such as porosities, cracks, and foreign particles in complex specimens. This technique plays a vital role in ensuring the integrity and reliability of materials used in critical industries. In this study, we focus on optimizing the film-to-X-ray source distance to enhance both detection sensitivity and accuracy. Various specimens, including stainless steel and Aluminum with different thicknesses and multi-layered configurations, were analyzed to determine the ideal parameters for reliable detection.

Medium and fast range films were employed to capture X-ray images, and the film-to-X-ray head distance was systematically altered to find the optimal point for visualizing indications. In addition, the X-ray shooting angles were modified, and the parallax method was used to minimize distortion and improve the clarity of subsurface features.

Results show that the optimal film-to-X-ray source distance varies significantly with specimen density, thickness, and material composition. By analysing the radiographs, we established empirical relationships between these parameters and the required focal distance. This research enables the standardization of film-to-X-ray source distance for future testing, reducing processing time and enhancing overall efficiency. This research contributes significantly to the development of standardized X-ray radiography protocols for NDT applications, particularly in critical sectors such as aerospace, automotive, and industrial manufacturing. The findings from this study will guide the development of standardized guidelines for selecting the optimal film-to-X-ray source distance based on specimen characteristics. By tailoring the distance to the specific properties of each specimen, inspectors can improve detection accuracy, minimize false positives, reduce processing time, and increase the overall efficiency and reliability of the testing process.

**Keywords:** X-ray radiography, non-destructive testing, film-to-X-ray source distance, subsurface indication detection, sensitivity, multi-layered specimens.



#### Development and Application of Eddy Current Testing for Helical Coiled Tubes of Steam Generator

**CP 74** 

THE ABSTRACT

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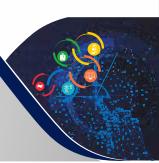
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NDE4.0 is the keyword in industry today. The author of this work has developed a cloud-based application, validated over two years on a major project by a renowned Indian projects company, which can be operated via any smartphone. Data related to the worksite, job details, shifts, equipment, probes, blocks, etc., is uploaded to the cloud database, making it accessible as dropdown options on the app. The UT operator can log test results through structured input forms, with data automatically archived on the cloud with a timestamp.

The application features include 'D' rating calculation, automatic interpretation of defect location and depth in the weld cross section, and remote printing of final reports, with the option to select multiple joints in one report. This tool has significantly reduced human error and effort, resulting in considerable savings in the cost and time of processing test observations. The cloud-based cumulative database can be accessed by authorized personnel anytime, anywhere. Lost printed reports can be easily verified for test history and re-issued. Traceability to operators, equipment, calibration, etc., is swift and precise, aiding in effective non-conformance root cause analysis.

**Keywords:** Ultrasonic, AWSD1.1, 'D' Rating, NDE4.0, Smartphone App, PWA, Automatic reporting, defect location, traceability.





#### Microcrack formation in Steel Fiber Reinforced Concrete Under uniaxial compression by monitoring Acoustic Emissions

**CP 75** 

THE ABSTRACT

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This article presents an experimental study on quasi-brittle deformation in cementitious materials, focusing on Normal Strength Concrete (NSC) and Steel Fiber Reinforced Concrete (SFRC) with a steel fiber content of 1.6% volume fraction. The quasi-brittle deformation is characterized by microcrack formation, during which stored strain energy is released as acoustic emissions (AE). AE waveform parameters were recorded during unconfined uniaxial compression of NSC and SFRC tested under the displacement control method at a rate of 0.004 mm/s. The test specimen was mounted with six AE sensors (54 kHz, resonant frequency), with three sensors on opposite faces. AE waveform parameters namely peak amplitude, counts, and AE energy were used to study the microcracking. AE waveform reflects the microcrack activity. It is observed that there is a significant AE energy released near the peak load in SFRC, leading to a considerable time for post peak softening. However, NSC showed significant AE energy in the pre-peak stage. The AE waveform related to SFRC had a higher number of ring down counts due to the presence of two-ended hooked fibers that contributed to fracture toughness. The compressive strength of SFRC increased by approximately 11% compared to NSC, indicating that steel fibers resisted crack propagation, resulting in a marginal improvement in compressive strength. The comparison of damage in SFRC and NSC showed that the presence of fibers slowed down the growth of microcracks. This reduction in microcrack propagation contributed to a delay in the final failure of the SFRC It was observed that SFRC provides resistance to microcracking, making it suitable for structural engineering applications.

**Keywords:** Microcracking, Steel Fiber Reinforced Concrete, Acoustic Emission, Damage, compressive fracture



#### Enhancing Subsurface Defect Detection in AA2219 Aluminum Alloy Welds: A Comparative Study of X-ray Radiography Techniques

**CP 76** 

THE ABSTRACT

G.Kamesh Guru<sup>1</sup>, T.Antony Prabhu<sup>1</sup>, Surya Prakash Singh<sup>3</sup>, P.Padmanabhan<sup>4</sup> and D.P Sudhakar<sup>5</sup> <sup>1</sup>ISRO Propulsion Complex, IPRC, Mahendragiri, India kamesh.guru@gmail.com

This study investigates the efficacy of X-ray radiography for accurately measuring the depth of subsurface defects in Gas Tungsten Arc Welded (GTAW) joints of AA2219 aluminum alloy, a material critical to the aerospace industry. Utilizing both medium-speed film and advanced digital radiography, the research aimed to detect artificial defects positioned at varying depths within 10 mm thick specimens.

A systematic approach was employed, systematically varying parameters such as voltage, current density, X-ray exposure angles, and incorporating the parallax method to optimize the detection of defects. The gray values captured from both radiographic techniques were meticulously compared to establish a reliable correlation between the density measurements and the depths of the defects.

The results revealed that the difference in gray values between the defects and the surrounding material serves as a dependable indicator of defect depth, showcasing a strong correlation between the density values and the actual depths of the defects. Notably, digital radiography exhibited enhanced sensitivity and improved depth resolution compared to traditional film methods, demonstrating its superior capability in defect detection.

This study underscores the potential of X-ray radiography as a precise tool for measuring subsurface defect depths in aluminum alloy welds, ultimately leading to reduced processing times and improved weld joint qualification standards. The findings aim to inform the development of optimized radiographic testing protocols tailored for aerospace applications, thereby enhancing the reliability and safety of welded structures in demanding environments. By advancing the understanding of defect detection methodologies, this research contributes to the ongoing efforts to ensure the integrity of critical aerospace components.

**Keywords:** X-ray radiography, gray value, sensitivity, digital radiography, aerospace, depth detection, non-destructive testing (NDT).





# Enhancing Subsurface Defect Detection in AA2219 Aluminum Alloy Welds: A Comparative Study of X-ray Radiography Techniques

**CP 77** 

THE ABSTRACT

G.Kamesh Guru<sup>1</sup>, T.Antony Prabhu<sup>1</sup>, Surya Prakash Singh<sup>3</sup>, P.Padmanabhan<sup>4</sup> and D.P Sudhakar<sup>5</sup> <sup>1</sup>ISRO Propulsion Complex, IPRC, Mahendragiri, India kamesh.guru@gmail.com

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**Keywords:** X-ray radiography, gray value, sensitivity, digital radiography, aerospace, depth detection, non-destructive testing (NDT).



## Nonlinear Ultrasonic Inspection of Areca Nut Natural Fiber Reinforced Composite Balustrades

**CP 78** 

THE ABSTRACT

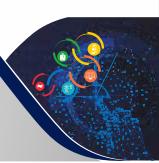
Kiran Kumar Amireddy<sup>1</sup>, V. Jaipal Reddy, Venkata Sushma Chinta, V. Sandhya Chaitanya Bharathi Institute of Technology, Gandipet, Hyderabad, Telangana, India ¹amireddykiran@gmail.com

Balustrades are key functional elements in architecture for improved protection and add aesthetic value to various types of buildings. Industrialization allows wide variety of materials in preparation of Balustrades for improved safety and style, but disposal of these composites (non-biodegradable) after its service life is a challenging task for materials engineers. Hence, researches are now concentrating on natural fiberreinforced composites as the alternate solution for sustainability and eco-friendly without compromising its strength and functionality.

In this paper we demonstrate the use the Areca nut natural fiber reinforced composites for preparation of composite laminates as an application of building blocks as Balustrades and also explains the investigation of these Balustradesfor its quality assurance. By using the Nonlinear Resonance Ultrasonic inspectionmethod (NRUS), we demonstrate the finding of defects like cracks, porosity, density variation, delamination and its location in the Areca nut fibre reinforced composite Balustrades. Also, we demonstrate the effect of nonlinear coefficient with delamination location in the multi layered composite sheet. Further, the same nonlinear coefficient variation with the present of defect type like, crack, porosity etc. in the composite laminates.

Keywords: Areca nut Natural fibers, Biodegradability, Nonlinear Resonance Ultrasonics, Delamination





# Implementation of Structural Health Monitoring using Distributed Fiber Optic Sensing on Composite Aircraft Structure

**CP 79** 

THE ABSTRACT

S Nadeem Masood, ParasuramHangal, Venkatesh S,Kotresh M Gaddikeri, Ramesh Kumar M, Srinivasa Vand Amitabha Datta\* Advanced Composites Division, CSIR-NAL, Bangalore \*amitabha@nal.res.in

The use of Carbon Fiber Reinforced Polymer (CFRP) composites material in primary aircraft structures has significantly increased over the past few decades. These composite materials offer considerable advantages, such as a high strength-to-weight ratio, as well as superior fatigue and corrosion resistance. However, despite these inherent benefits, in service the CFRP structures are prone to have disbond and delamination due to impact, which pose risks to structural integrity if go undetected.

This paperpresents the development of a Structural Health Monitoring (SHM) system for composite aerospace structures using distributed fiber optic sensors. The process began by identifying critical damage-prone areas in the aircraft and utilizing distributed fiber optic sensors networkduring static load testing to record referencestrain data. A sophisticated algorithm, developed using MATLAB and Python, was employed to detect damage size and location with high precision.

The research was conducted on a home-built full scale SARAS Horizontal Tail, where sensor network bonded to the structure. By strain field measurements one need to identify damage zones. Our approach extends the Local Point Autocorrelation (LPA) technique by integrating clustering algorithms and convex hull analysis for enhanced damage detection. The methodology utilizes Delaunay triangulation to map strain variations, with a Hausdorff distance-based weighting system to identify damage regions. Validation was performed on experimental data collected from distributed fiber optic sensorssegments bonded to the structure.

This work demonstrates a significant advancement in SHM for CFRP composites, particularly for systems experiencing complex loading conditions and multiple damage scenarios, enhancing the in-service monitoring capabilities of aerospace structures.

**Keywords:** CFRP composites, Structural Health Monitoring, Fiber Optic Sensors, Barely Visible Impact Damage, Delaunay Triangulation, Clustering Algorithms.



### Normalizing Rolling of Plates And Its Significance To NDT

CP 80

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THE ABSTRACT

Paper With Title Normalizing Rolling Of Plates And Its Significance To NDT Will bePresented Under Topic Quality Control And Quality Assurance.

The Purpose Of This Paper Is To Highlight The Recent Developments In Plate Rolling Process Performed By Rolling Mills Based On The Bureau Of Indian Standards Act, 2016 And Its Significance During Ultrasonic Testing. The Paper Will Highlight How The Plate Rolling Or Supply Condition With Or Without Heat Treatment Influences The Acoustic Properties Including Sound Velocity and Attenuation Characteristics During Ultrasonic Testing. The Paper Will Delve IntoVarious aspects Like History Behind Compulsory Use Of Standard Mark Under License From Bureau For Steel And Steel Products, Reason For Mandatory Use Of Standard Mark, Background For Various Rolling Process Like Normalizing Rolling, As Rolled, Hot Rolling, Controlled Rolling, Thermo-Mechanical Control Process Etc. Paper Will Also Address Key Differences Between Each Rolling Process, Manufacture And Supply Condition Including Heat Treatment Condition Of Plates As Per ASME And IS Standards. Under Non-Destructive Testing The Paper Will Cover Working Principle Of Ultrasonic Testing Including Applicable ASME Code And Standard For UT Of Plates, Applicable ASME Specification For Plates, RequirementsOf Ultrasonic testing As Per ASME SEC V Including Essential Variables, Requirements To Be Considered While Preparing Calibration Blocks, Performing Ultrasonic Testing And Its Significance With Respect to Rolling Process And Heat Treatment Condition Of Plates. It Is Observed That Suppliers Are Using Calibration Blocks Manufactured FromNormalized Rolled Plates, For Ultrasonic Testing Of Normalized Heat Treated Plates. This is Non Compliance To ASME Code Requirements, Since Normalizing Rolling Is Not Considered As Normalized Heat Treated As Per ASME Code, And Heat treatment Is Essential Variable for Calibration Block. Therefore, Calibration Block For Ultrasonic Testing Of Normalized Plate Shall Be Prepared From Normalized Heat Treated Plate Only. Post Completion of Paper Presentation; The Participants Will Be Able To Understand The Significance Of Rolling Process During Manufacturing Of Plates, Difference Between Normalizing Rolling and Normalizing Heat Treatment And How Its Influences The Ultrasonic Test Results In Terms Of Accuracy, Consistency In Ultrasonic Signals And ASME Code Compliance.

Keywords: Normalizing Rolling, Ultrasonic Testing Of Plates, Calibration Block, ASME Code Compliance.





# Assessment of Integrity of FCCU Cold Wall Riser thruFinite Element Analysis

**CP 81** 

THE ABSTRACT

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Fluid Catalytic Cracking Unit (FCCU) is considered to beheart of any modern refinery. Riser-Reactor is one of the most important equipment of FCCU in a refinery. In one of the refineries, FCCU Riser had hot spots on its shell which were a point of concern for its operators and maintenance team. To predict the creep life of Riser-Reactor section of FCC unit with hot spots at identified regions for safe plant operation, Thermal-Displacement analysis of Riser reactor section was carried out in below mentioned cases

- a) Thermal + Pressure + DW (without cooling effect on hotspot region)
- b) Thermal + Pressure + DW (with cooling effect on hotspot region)

The material properties of shell material (SA 516 Gr 70) of riseris UTS-485 Mpa, Max allowable stress at 250 °C- 288 MPA and Max. allowable stress at 360°C- 236 MPA. Certain assumptions taken during FE analysis. comparison of Von-mises stress values was done in both cases with or without external cooling. With external cooling, maximum von-Mises stress at the hotspot region was 141 MPa which is less than the allowable stress of 236 MPa. Without the external cooling, maximum von-Mises stress at the hotspot region without cooling effect was 198.1 MPa which is less than the allowable stress of 236 MPa. In both cases, stress values were found below the limit. However, considering similar stress exposure, creep life for shell in Case-A was observed 3 years. For Case-B where external cooling has been used to reduce stress, have shown creep life of shell about 15 years. The subject case study is one of the methods to analyze "Hot spots" thru Finite Element Analysis. This method can be chosen as one of the Engineering solutions for assessment of high stressed regions in the equipment being operated in hot spots condition.

Keywords: Hot Spots, Cold Wall design, FCCU Riser, Finite Element Analysis, Creep Life

(A" Hot Spot" is in this context a geometric singularity where high stresses are confined to a small area. This area stands out as it mostly represents stresses that exceed the allowable limit if not measured and controlled accordingly.)



## Role of Nde in Detecting Quality Problem in Heavy Steel Forgings

CP 84

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Manufacture of Large steel forgings involve melting and refining of large volume of steel, strict process control on ingot making, elaborate and long forging process, lengthy annealing cycle and finally the quality heat treatment.

Due to numerousvariables, quality problem are segregation primary and secondary shrinkage, flakes partially broken dendrites, non-metallic inclusion etc. By adequate process control and use of latest technology, the quality problem mentioned above can be minimized. Nondestructive Evaluation (NDE) and monitoring of problem by ultrasonic right from the beginning can help guide future course of action. Also, MPT and borescope help in analyzing and finding solution to these quality problems.

Primarily most of the internal flaws can be easily detected by ultrasonic testing method. Being a versatile method, the exact nature of flaws, their location and orientation and source of such flaws can be easily ascertained. Evaluation of internal quality can be done from the very beginning. Even the ingot can be teste by low frequency ultrasonic wave and general quality can ascertained.

If a major flaws such as piping extending to a considerable length of the ingot, segregation pattern, excessive non metallic inclusions are detected at this stage, remedial measures can be taken. Normally heavy ingots are transferred to the forge shop in hot condition, but if the melting history of the heat is bad it can be preliminarily forged to any intermediate size of evaluation by ultrasonic method. After forging and controlled cooling, the forgings are subjected to ultrasonic testing in selective manner to know the internal quality.

In the present paper various type of internal and external defects occurring in heavy forgings will be detailed their source and remedial actions to prevent such flaws will be discussed in detail.





# Radiography Evaluation of Defects in Carbon Composite Motor Case at Different Processing Stages

**CP 85** 

THE ABSTRACT

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The composite motor cases are used in various launch vehicles owing to their advantages such as high strength, high stiffness, low density etc compared to metallic motor cases. Radiography testing of composite motor cases is carried out at different stages of qualifications, as before and after proof pressure testing, after structural load testing etc, is carried out at different stages of qualifications as before and after proof pressure testing, after structural load testing etc, to reveal the defects and comprehend their growth under different testing conditions. In the initial phase of realization, the motor case will be subjected to inspection at multiple stages to study the defect profile that will aid in finalizing the process parameters, such as the optimal curing time and temperature, the best resin and fiber combination, and the most effective manufacturing techniques.

Fiber Glass-Epoxy motor case is used in many launch vehicles for which the process is standardized, whereas carbon Epoxy motor case is currently undergoing the developmental phase. Hence, the Carbon-Epoxy motor case is thoroughly inspected at multiple stages of the qualification process. In the first few motor cases developed, specific observations were observed that were not seen in the FG-Epoxy cases. Further, deviations occur in some types of defects at different stages of examination.

This paper presents a case study where defects are observed in Carbon-Epoxy motor cases in radiography before PPT. Some defects like porosities between the layers are found to have no changes after PPT but it was observed that few of the delaminations were closed at this stage. Also, some new observation like interface separations are found to have formed after structural test. In the presence of such defects, the motor case will not be able to withstand the design load and may lead to failure under service conditions. It was observed that motor cases with severe porosity could not withstand the PPT load and needed improvement. However, most of the delaminations observed are found to be closing under pressure and withstood the load. Whereas, separation formed at the critical interfaces are detrimental which demands process improvement. These findings underscore the importance of understanding defect profiles and their implications for motor case design.

**Keywords:** Radiography testing, composite motor case, Carbon-Epoxy, delaminations, proof pressure test, structural test, etc.



# Advancement in Quantification of Early-Stage Local Damages in Metals through Nonlinear Ultrasonic Inversion and Bayesian Analysis

**CP 88** 

THE ABSTRACT

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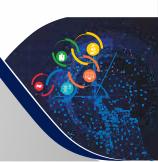
Quantifying micro- and meso-scale damage in metals during early fatigue stages using nonlinear ultrasonic testing is challenging due to the complex nature of micro-damage such as dislocations and microcracks. These initial damage sites localize in specific material regions, concentrating plasticity before large-scale cracking appears. Although researchers often analyze this damage by measuring harmonic responses, the damage is not uniformly distributed as commonly assumed. Ultrasonic wave interactions with these nonlinear damage regions reveal that as the damage grows, the amplitude of forward-scattered waves increases, but accurately quantifying the damage size is difficult due to experimental constraints and the complexities of third-order elastic constant calculations.

To address this, a method based on harmonic scattering principles in nonlinear ultrasonics has been proposed to quantify localized damage size. This technique, validated with finite element models, employs deterministic inverse problems to solve nonlinear optimization challenges, both constrained and unconstrained, to estimate localized damage. Due to the intense nonlinearity in these objectives, solution reliability is inherently challenging, which has led to significant refinements in the approach to improve results in complex configurations. In practical applications, the parameters, including damage size, input frequency, wave velocity, and harmonic amplitude ratios, are usually measurable with accuracy. Nonetheless, real-world experiments introduce uncertainties, such as material-specific variations in wave velocity. Models that simplify local damage as a linear strip deviate from real conditions, introducing further complexity in precise damage sizing.

This research validates the effectiveness of the proposed methodology for early-stage damage quantification through nonlinear ultrasonics, accounting for uncertainties common in experimental scenarios. A suite of forward models was solved to capture the problem's nonlinear traits, highlighting the sensitivity of parameters within the objective function. For highly nonlinear problems, Bayesian analysis provides robust uncertainty quantification, integrating synthetic data distributions from Gaussian to Logarithmic through Affine Invariant Ensemble Sampler (AIES) methods and MCMC solvers. Bayesian methods surpassed deterministic solvers like MATLAB's fmincon, which struggle with local minima in highly nonlinear spaces. Uncertainty levels up to 10% in experiments and 5% in model parameters further demonstrated Bayesian inversion's superior adaptability in complex, nonlinear inverse problem-solving.

Keywords: Nonlinear Ultrasonics, Harmonics Scattering, and Uncertainity Quantification.





# Microwave Non-Destructive Evaluation of Bituminous Concrete (BC) Pavement Layer Using Machine Learning

**CP 89** 

THE ABSTRACT

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Accurately assessing flexible pavement layers with distinct structural and material properties is essential for optimizing load distribution, durability, and overall performance. A typical flexible pavement comprises four layers: a 50 mm bituminous concrete (BC) wearing course, a 150 mm bituminous macadam (BM) binder course, a Water Bound Macadam (WBM) sub-base, and a soil subgrade providing foundational support. This study emphasizes evaluating the BC layer, crucial for surface quality and structural integrity. We utilize a novel non-destructive evaluation (NDE) technique based on microwave reflection coefficient measurements using an open-ended rectangular waveguide (OERW) probe. This method enables precise determination of the BC layer's density and thickness, which are key to pavement performance. Testing is conducted within the X-band frequency range (8.2 - 12.4 GHz), suitable for high-resolution analysis. A machine learning-based approach complements the microwave NDE technique to enhance the simultaneous estimation of the BC layer's density and thickness. The algorithm is trained on a comprehensive dataset of BC samples, with density variations from 2.2 g/cm³ to 2.5 g/cm³ and thicknesses from 3 cm to 15 cm. The quality of the BC layer relies on bitumen content and workmanship during mixing and compaction; lapses in either are reflected in the density of the bitumen mix. To assess the quality of the BC layer, we determine thickness and density from field samples, which measure 15 cm x 15 cm and contain aggregates of specified gradation (nominal size under 20 mm), with bitumen as the binder. Samples are prepared with controlled bitumen content ranging from 3% to 6%, creating density variations. Experimental results show a strong linear correlation between the reflection coefficient and variations in density and thickness. The study confirms that microwave NDE, enhanced by machine learning, provides accurate assessments of pavement layer properties. These findings affirm the method's effectiveness in real-world applications, making it a promising solution for improving quality control and structural evaluation of flexible pavements.

**Keywords:** Microwave Non-Destructive Evaluation (NDE), Bituminous Concrete (BC), Machine Learning, Pavement Structures, Rectangle Waveguide.



#### Application of Phased Array Ultrasonic Testing in NDE of Liquid Propulsion Systems: Case Studies

**CP 90** 

THE ABSTRACT

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Though redundancy is built-in to ensure satisfactory performance of Liquid Propulsion Systems for Launch Vehicles, there are components/assemblies which are sources of single point failure. Non Destructive Testing & Evaluation plays a vital role in ensuring the quality and reliability of such components/assemblies. Since exotic materials and intricate geometries are adopted from the functional requirements point of view, Non Destructive Evaluation (NDE) is extremely challenging. Most often NDE scrutiny is applied at different stages of realization and the challenges are multifold as the component/assembly is turning into a value added launch vehicle system.

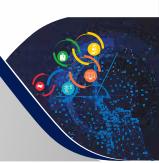
Among the spectrum of NDT techniques available for the integrity assessment of mission critical and fracture critical liquid propulsion system elements, Ultrasonic NDE (UNDE) has got unique and inevitable ranking due to its capability to reveal even tight planar flaws, which otherwise may not get reliably detected by any other conventional NDT techniques including Radiography. Phased array ultrasonic testing (PAUT) utilizes transducers with multiple elements, which can be pulsed separately with suitable time delays, electronically imparting capability to steer, sweep and focus the resultant acoustic waves. In addition to the enhancements in sensitivity and detectability, productivity can also be improved by virtue of its reduced inspection time and larger volume coverage.

This paper describes selected case studies portraying successful adoption of phased array UNDE, covering variety of applications in terms of materials (ferrous, non-ferrous and super alloys), processes (both fusion and solid state welded) as well as challenges and/or novelty involved. Application of PAUT to accurately characterize a longitudinal weld crack observed in the GTAW joint of a "fully value added" AA2219 Cryogenic propellant tank is discussed. PAUT assessment assisted in precise quantification facilitating successful elimination of the crack through satisfactory weld repair, qualifying the tank for flight usage. The structural integrity of martensitic PH stainless steel GTA Welded assembly with complex geometries not accessible for radiography has been ensured using PAUT, adopting customized test approaches. Challenges in PAUT of Ni-base super alloy GMAW joints with complex geometries for high pressure & temperature application has also been discussed. Also development & implementation of PAUT procedure for the evaluation of Friction Stir Welded (FSW) joints on AA2219 alloy propellant tanks is discussed in brief.

These case studies re-emphasize the role of advancements in NDT domain and NDT community in the success of Indian space programme.

Keywords: Phased Array UT, Liquid propulsion systems, Launch vehicles, GTAW, GMAW.





# Thz Image Enhancement Techniques for Nondestructive Evaluation of GFRP Composites

**CP 91** 

THE ABSTRACT

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Nondestructive evaluation (NDE) of glass fiber reinforced polymer (GFRP) composite material is of significance during the manufacturing stage, as well as the service life of these materials in various aerospace and defense components. Although several NDE techniques are already available for composite inspections, namely ultrasonic testing, X-ray imaging, and thermography, there are a few limitations associated with each of them, such as the need for coupling fluid, the use of ionizing radiation, or the inability to effectively penetrate the composite material, etc. Hence, there is a demand for a noncontact NDE with higher penetration and imaging resolution for composite inspection employing nonionizing radiations.

Terahertz (THz) radiation, with frequencies from 0.1 to 10 THz range, is non-ionizing and is a potential candidate for this NDE application. The suitability of employing THz imaging for the composite inspection has been well-proven. However, there are a few limitations to its widespread industrial deployment, namely (i) poor THz image quality, (ii) high system cost, and (iii) high image acquisition time. The THz images have poor contrast and resolution; hence, in this work, efforts have been made to enhance the image quality, thereby aiding in the ease of defect identification/detection. The raw THz images acquired from the continuous-wave THz imaging system at different frequencies are subjected to a series of image operations – (i) scale adjustment, (ii) denoising, (iii) image segmentation, (iv) contrast enhancement, and (v) edge detection. Each image processing operation has been optimized for the THz NDE images, and it has been observed that the processed images have improved contrast and refined edges, enabling the accurate detection/identification/classification of defects in composites.

**Keywords:** Terahertz, GFRP (Glass Fiber Reinforced Polymer), Continuous-wave THz imaging, Image enhancement

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## Solving 2D Corrosion Mapping Ultrasonic Inspection Challenges

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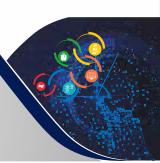
THE ABSTRACT

Ultrasonic corrosion mapping inspection using conventional single-element UT probes is slow and only capable of acquiring low-density data. Inspecting large areas using conventional UT typically requires a configuration involving complex, expensive, and difficult-to-set up motorized scanners. Offering a wider beam coverage than conventional UT, phased array ultrasonic testing (PAUT) has gained popularity in recent years for corrosion mapping, as it helps improve inspection rates while increasing data quality. Although the wider beam is an advantage, the probe still needs to be moved sideways between each scan line to perform 2D mapping of the targeted inspection area. To encode the probe's position on two axes, a typical phased array search unit needs to be mounted on an external dual encoded scanning system, further increasing the inspection costs and complexity. Evident has developed a solution to this problem - a new phased array scanner with wide coverage phased array probe and two integrated encoders to record its position on the part for both x- and y-axis scanning, thereby removing the need for an auxiliary scanner it allows for remote inspection of difficult-to-reach surfaces such as tank walls and pressure vessels, It's on-board controls and intuitive software interface makes it easy to setup and user friendly.

This presentation will provide details on the different innovations implemented in this new system and explain how it can be used for corrosion inspection withincrease in scanning speeds, productivity and data quality while reducing the inspection time, costs and complexity it is truly easy-to-deploy fully encoded 2D corrosion mapping system.

**Keywords:** Corrosion Inspection Phased Array





#### Thickness Profiling of Multi-layer Functional Coating using THz-Time Domain Spectroscopy System

**CP 93** 

THE ABSTRACT

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Multi-layer functional coatings are engineered coatings with multiple distinct layers, each offering specific properties or functionalities. These coatings find extensive applications in electronics, optics, and protective surfaces. The thickness of each of these layers has to be precisely controlled so that the functionality of the coating is preserved in the sample. Hence, there is a requirement for a nondestructive evaluation (NDE) technique to precisely estimate the thickness of each layer in the multi-layer functional coating nondestructively in a non-contact manner. Terahertz (THz) NDE employing THz waves in the frequency range of 0.1 to 10 THz is a viable technique for such applications.

Here, a two-layer functional coating has been precisely characterized using the THz time-domain spectroscopy system in reflection mode. The reflected THz picosecond pulses are analyzed to extract the individual reflection peaks from the time-of-flight information. However, due to optically thin coating layers, the individual reflection peaks tend to overlap with each other, thereby making the direct thickness estimation a challenging task. Advanced signal processing techniques, namely the deconvolution technique, can help resolve the individual reflection peaks from the overlapped time-domain data. Hence, a sparse deconvolution technique with iterative soft thresholding operation has been employed to resolve the reflection peaks corresponding to individual interfaces in the two-layer coated sample. These measurements have been repeated at multiple points on the sample, and the thickness profile of each layer has been estimated, which enables us to identify points/regions where thickness deviations are high, and thereby, corrective measures can be taken accordingly.

**Keywords:** Terahertz (THz), Time-domain spectroscopy (TDS) system, Sparse deconvolution, Thickness profiling



#### High-Resolution and Real-Time Localization of Steel Rebars in Reinforced Cement Concrete Structures using Finite Mixture Models to Analyze Pulsed Eddy Current Sensor Data

**CP 95** 

THE ABSTRACT

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Pulsed eddy current (PEC) inspection provides a non-invasive method for evaluating steel rebars in reinforced cement concrete (RCC) structures. A pair of excitation and detection coils are typically used in a PEC system to interrogate the rebars and estimate concrete cover thickness and rebar diameter. Line and grid scan profiles are generated by moving the PEC sensor across the structure's surface, continuously collecting signals from the detection coil. When rebars are closely spaced to each other, eddy currents are induced in multiple rebars by the current pulse in the excitation coil, which in turn simultaneously contribute to the detection coil output signal. This interference results in inaccurate rebar localization. Commercially available PEC tools typically employ multiple coil configurations or arrays of sensors, thereby adding to the cost of the solution. In this study, we present the utility of employing finite mixture models (FMMs) for enhancing rebar localization performance using a single pair of excitation and detection coils iniPEC, a low-cost handheld PEC device developed at IIT Bombay. The signal from each rebar is analyzed as a distribution, and the mixture of distributions arising from multiple rebars are evaluated by a customdeveloped model to effectively separate overlapping signals, allowing for accurate rebar localization and differentiation. Using an accompanying wireless tablet device for implementing the localization algorithm enables real-time localization of rebars using wireless display for the benefit of site supervisors and engineers. We demonstrate improved performance compared to some commercially available products, especially for rebars with cover depth exceeding 65mm.

Keywords: Pulsed eddy current, non-destructive testing, finite mixture models, rebar localization





## Conventional Ultrasonic Imaging Applications Using Ultra-Portable Ultrasonic Device

**CP 96** 

THE ABSTRACT

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Wind turbine blades are a crucial component of wind turbines, which converts the Kinetic energy of the wind into mechanical energy and then to electricity. The curved design of the airfoilgenerates lift by creating a difference in pressure as the wind flows over them. As the wind industry evolves, ongoing innovations aim to enhance blade performance. Composite materials are one of the best used materials in wind blade manufacturing because of their higher strength and light weight for power efficiency.

Corrosion is one of the significant challenges across various industries which makes the parent material to deteriorate and leads into catastrophic failure during in-service. Corrosion affects applications such as pipelines, oil storage tanks and industrial machinery which leads into costly maintenance and repairs. Especially in the Oil&Gas industry corrosion can cause safety incidents and environmental damage.

Effective ways of inspecting corrosion and wind turbine blades are crucial to prevent failures and increase the life span of the components. As part of this paper, we will discuss about the inspection of corrosion and wind turbine blade base metalinspection as an application study using advanced tools such as high-resolutionimaging such as B-Scan (Side view) and C-Scan (Top view) with full A-Scan capture using ultraportable conventional Ultrasonic testing flaw detector and the On Device analysis for defect identification and measurement. The specimen and components were tested using ultrasonic immersion lab tank system and manual ultrasonic testing and the results are analyzed with the actual specifications of the defects.

Keywords: Wind turbine blade, Corrosion, Ultrasonic Testing, B-Scan, C-Scan



### PZN-PT based Surface Acoustic Wave Transducer for NDE Application

**CP 97** 

THE ABSTRACT

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Relaxor-ferroelectrics with compositions near morphotropic phase boundary (MPB) exhibit high piezo response due to relatively easier alignment of the dipole moments. 0.91Pb(Zn1/3Nb2/3)O3-0.09PbTiO3 (PZN-PT) is one such composition which has huge piezo coefficient values of d33 exceeding 2000pm/V and electro-mechanical coupling coefficient of 95% which are 5-6 times higher than that of PZT ceramics. Materials with such high piezo coefficients find immense usage in monitoring of fuel sub-assemblies in the sodium environment within the nuclear reactor, structural health monitoring, and buried pipe line inspection. In reactor environment the operating temperatures can be as high as 600°C. We need to have piezo devices which either operate at this temperature or placed at ambient working temperature and are able to transmit the ultrasound waves into the sodium pool. The desired piezo transducer should transmit surface acoustic waves (SAW) via a waveguide. Towards this a prototype SAW transducer has been made fromin-house grown PZN-PT [1]. PZN-PT single crystals are grown by adopting a novel bottom cooling high temperature spontaneous solution growth processwhich establishes an inverse temperature gradient and circumvents multi nucleation yielding large size single crystals.

PZN-PT has highly anisotropic physical properties, with the desired piezo properties required for SAWdevice along the (001) crystallographic orientation. PZN-PT waferswere characterised for their polarization, piezo electric coupling coefficient and resonance frequency. SAW transducer was made with a (001) oriented and poled PZN-PT single crystal of dimension 7 mm X 7 mm X 0.6 mm. SAW transducer was attached to a one-meter-long wave guide dipped in water that simulates a similar fluid environment under which the transducer has to work in the reactor. The electro-acoustic parameters of the transducer were tested at a frequency of 2.8 MHz with an applied voltage of 400V. The acoustic echo spectrum produced by the in-house developed SAW device matches well with the spectrum produced by the commercially available probe.

#### Reference:.

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P. Vijayakumar, C. Manikandan, R.M.Sarguna, Edward PrabhuAmaladass, K. Ganesan, Varsha Roy, E.Varadarajan, S.Ganesamoorthy.

Journal of Crystal Growth, 626, 127462 (2024).





## Testing Machines for Highspeed In-Line Ultrasonic Inspection of Bar and Wire Stocks

**CP 98** 

THE ABSTRACT

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Ultrasonic testing (UT) of bar and wire stocks ensures quality and reduces wastage in finished products. Typical UT standard specifications in automotive and aerospace applications require the ultrasonic testing of bar andwire stock with an exceptionally reliable detection of small defects over a wide depth range in thematerial. Typically, such inspections are performed with immersion tanks using aset of probes optimized for each depth. However, for industrial applications this is not economical due to disadvantages such as slow inspection speed, the time-consuming inlet and outlet process, complicated mechanics, and significant costs involved in using specialized probes.

This paperdetails an in-line phased array inspection system using a radial arrangement of phased array probes with integrated multi-zoneinspection, whichis based on the Krautkrämer ROWA™ Ux machine. After a brief description of the setup, special focus is provided on UT concept optimized with respect to a multi-zone inspection which includes a dedicated automatedadjustment of the system that results in high reproducibility, reduces human errors and a fast changeover time. Furthermore, powerful electronics allow flexible settingof focus point, aperture size and filtering. This significantly reduces the need for specialprobes and the number of test shots by means of digital depth focusing (DDF). Atthe end, the flaw detectability in different depths and the improved signal-to-noiseare illustrated. The increased inspection speed and the higher probability of detection achieved by parallel evaluation of multiple focal points is illustrated. A comparison of the achievable inspection speedsof the optimized multi-zone inspection system is presented.

Keywords: Testing machines, Digital Depth Focusing (DDF), Bar, Wire, Billets



#### Ultrasonic Inspection Methodsin Aerospace Industry and the Benefits of Reverse Phasing Contour Adaptation Technique for Composites

**CP 100** 

THE ABSTRACT

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Maintaining the quality of the components in the aerospace industry is extremely critical due to factors such as people's safety and performance. Either during manufacturing or in-service rigorous testing of the components with the help of non-destructive testing methods is crucial. Multiple components are used in the aerospace industry, where Ultrasonic Inspection is one of the most used non-destructive testing methods which helps in flaw detection in these components. Depending on the type of component multiple solutions are required to check the quality of all different aerospace components. There are multiple components in the aerospace industry such as wings, elevators, flaps, wing blades, wing tips and fairings.

In this paper, we will discuss about what are different probable solutions to detect the flaws in most of the aerospace components. Besides, we focus on reverse phasing contour adaptation technology which is driven by software to measure the time of flight from the probe to part's surface and use this information to adjust the delay laws dynamically during the scan as per the radius of curvature of the contour. Reverse phasing contour adaptation helps in radius inspection, allows in adjusting the misalignment tolerance and gives better results in the detection of inclined flaws. We will discuss how the phased array squitter system helps in increasing the scan speed when compared with single channel squitter system and, we will do a comparison of test results between with RPCA and without RPCA. We willdiscuss the robustness against misalignment of Reverse Phasing Contour Adaptation (RPCA) and the detection of inclined flaws in complex contoured parts.

Keywords: Matrix Array Probe, Reverse Phasing Contour Adaptation, Aerospace, Ultrasonic Inspection





### Ultrasonic waveguide sensors for fluid level and temperature measurements

**CP 101** 

THE ABSTRACT

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This paper describes an ultrasonic waveguide concept to measure the temperature and fluid level. The longitudinal L(0,1), torsional T(0,1), and flexural F(1,1) wave modes were propagated simultaneously in these waveguide configurations using a pulse-echo (PE) technique using a single shear transducer. A flexible stainless-steel wire (diameter 1.2 mm) was used to develop the ultrasonic waveguide sensor using straight and helical configurations. The transducer was oriented 45 degrees to the waveguide axis for transmitting and receiving all three wave modes simultaneously. Initially, we used the Finite Element (FE) approach to understand the wave propagation behavior in the waveguide and its various reflectors. In this work, two or three wave modes were used simultaneously to study the ultrasonic reflections from the reflectors and make appropriate waveguide sensors. We have performed the fluid level and temperature measurement experiments simultaneously with respect to the amplitude drops and time of flight shift of the received sensors' signals. We have used all three wave modes, L, T, and F, to identify the better reflector for making the ultrasonic temperature sensor. The developed sensor must be calibrated based on fluid level and fluid temperature using conventional temperature sensors (thermocouples) and approaches to obtain the calibration equation or chart to perform further experiments. These measurements were compared with conventional temperature sensors and approaches. The developed sensor technique is a simple design, concept, and cost-effective method. This technique can be used simultaneously in flammable or hazardous regions, suchas fuel tank temperature, level sensing, hot chamber temperature, and viscosity measurement, especially in the oil and gas industries.

**Keywords:** Ultrasonic-waveguide, Sensors, Fluid level, straight and helical waveguides, FEM, Temperature.



#### Use of Backwall Echo Attenuation Methodin Ultrasonic Testing of Ductile Iron Castings

**CP 102** 

THE ABSTRACT

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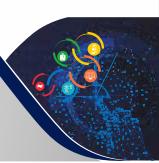
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In this paper we talk about the importance of using Backwall Echo Attenuator (BEA) during the testing of ductile iron castings using ultrasonic testing. Ductile iron castings are versatile and durable material which is widely used across different industries because of their exceptional mechanical properties. During the casting process, Magnesium addition transforms the graphite structure into nodules that results in enhancing the ductility and strength when compared with cast iron. But during this process there is a high possibility of getting common casting defects such as porosity, shrinkage, cracks, and fissures. Ultrasonic testing is one of the best suited NDT method to inspect defects in castings.

Quantification of these defects that formed during manufacturing or in-service of the components are critical in-order increase the life span of the material. With the conventional technique itschallenging to identifyresolve the indications as it is closely located with backwall. One of the special functions that helps in analyzing such indications better is Backwall Echo Attenuation. Identifying the defects that are close to the backwall echo is important to avoid false calls because of backwall signal. Sometimes it will lead into false calls because of lower signal strength of the defect when compared with backwall echo signal of the test specimen. It is difficult to monitor the BW echo reduction when doing the inspections especially in DGS evaluation mode and the standards practice for this method. As part of this paper, we will study the advantages of using the Backwall Echo Attenuation method on reading the Backwall echo and defect echo with good resolution.

Keywords: Backwall Echo Attenuator (BEA), Castings, Ductile Iron, Backwall Echo





#### Phased Array UT Solution For Composite, Corrosion And Sheet Metal Applications With Innovative Ultra-Portable Electronics

**CP 103** 

THE ABSTRACT

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The RotoArraycomPAct is a phased array probe with integrated electronics and a USB-C connection, offering excellent portability and user-friendliness as the innovative next generation Phased Array ultrasonic inspection where the complete Phased Array system is miniaturized in a single probe. As entire device hardware is moved onto probe there is a significant improvement on SNR. This disruptive patented and industry-first technology compresses the PA electronics into a half-thumb-sized chip which provides great reduction in volume and on power consumption. It can be easily connected to a tablet via USB port which ensures maximum portability. As an industry first it combines the performance of a complete Phased Array inspection system in a single probe thanks to miniaturized instrument electronics. With RotoArray comPAct the Phased Array inspection workflow needs less equipment and becomes more flexible. RotoArray comPAct ensures reliable and convenient flaw detection with maximum portability, minimum weight and excellent connectivity for time- and cost-efficient manual phased array inspections.

As part of this paper, we will discuss about the validation and evaluation of different applications like Plexi glass, composite materials, corrosion, and sheet metal testing with the help of RotoArraycomPAct probe. Focus will be mostly to detect adhesive or bonding defects in composite materials, reliably identifying delamination, bonding defects, and volume defects. Calibration blocks are created with artificially induced defects to simulate corrosion, delamination and disbonding. Delaminations, bonding defects and volumetric defects are very well detected with the help of RotoArraycomPActprobe and the results are more reliable. This makes the RotoArraycomPAct as a versatile tool for various non-destructive testing scenarios.

Keywords: RotoArray comPAct, Composite, Corrosion, Bonding, Delamination



# In-House Development of a PC-Based Ultrasonic Flaw Detection System for Nuclear Component Testing

**CP 104** 

THE ABSTRACT

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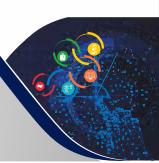
This paper presents the in-house development of a PC-based Flaw Detection System for automated nondestructive evaluation (NDE), tailored to meet the demands of complex ultrasonic testing (UT) applications. Conventional flaw detectors typically output only gated amplitude data, limiting their effectiveness in automated inspections where detailed defect size and depth mapping are critical. To overcome these limitations, the developed system integrates a PCI-based UT plug-in board with necessary interfacing hardware and specialized software for system configuration and signal capture, including amplitude, Time of Flight (ToF), and A-scans. This versatile system supports further development of automated NDE systems for applications such as PHWR welds, tubes, billets, and dimensional inspections. This paper demonstrates the application of the system to end closure welds in Pressurized Heavy Water Reactor (PHWR) fuel pins, delivering high-resolution depth mapping for more reliable automated inspections.

The data acquisition (DAQ) system includes two specialized software modules: (a) a high-speed, automated module for real-time defect detection and classification, and (b) an encoded B-scan module for detailed defect characterization. A user-friendly graphical interface developed in Visual C# streamlines UT system setup, while an advanced algorithm effectively differentiates true flaws from geometric echoes, enabling accurate defect identification. The encoded B-scan facilitates comprehensive defect mapping with precise size and location measurements, reducing the need for labor-intensive metallographic analysis.

The adoption of this PC-based flaw detection system as part of in-house automated inspection solutions has proved integral for diverse applications, providing a scalable, high-performance solution well-suited to high-volume nuclear component inspections. Its deployment contributes reducing reliance on specialized manual reviews, supporting continuous improvement in critical NDE processes.

Keywords: Flaw detection, ultrasonic testing, data acquisition, Time of Flight, PHWR, B-scan





#### Smart Inspection of Rail Wheels Using Matrix Array Ultrasonic Probes

**CP 105** 

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THE ABSTRACT

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Train wheels are one of the most safety critical elements of rolling stock as they are exposed to high stress, particularly due to increasing speeds, loads and distances. Global railroad standards require these assets to be ultrasonically inspected on a regular basis. Rail operators, manufacturers and maintenance facilities are constantly seeking increased productivity and improved quality using non-destructive testing solutions. Axial and Radial inspection of these components is very common practice in the industry because of the extension and tightening of the components. Extension and tightening of common standards for ultrasonic inspection during operation and maintenance. Axial inspection of face and flange, radial inspection of tread and web are the critical components to be considered as part of the wheel inspection using Ultrasonic testing.

Matrix Array Ultrasonic probes provide simplified mechanics, compact design, electronic beam angles can be optimized in a better way and better projection of Ultrasonic data. This technology helps in the reduction of linear array probes required for the inspection and beam angle optimization helps to detect defects of different types and locations. Matrix Array technology provides high precision and reliable results for both radial and axial inspections. Also, these probes can be adapted to different wheel geometry and defecttypes without mechanical settings.

As part of this paper, we will talk about the inspection of rail wheels and different industrial solutions with the help of matrix array probes. We will discuss the complete inspection without removing the wheelset from the rail car, which provides maximum inspection throughput.



#### Analysis of Ultrasonic Guided Wave Resonance Based Technique in Localizing Defects in Thin Metallic Plates

**CP 106** 

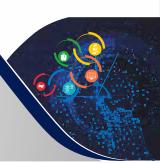
THE ABSTRACT

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Ultrasonic guided wave is a popular Non-destructive testing (NDT) technique which has been used for damage localization across various industries. This method is particularly useful for inspection of large structures, as it can travel a long distance through any guided medium. Guided wave based inspection can not only detect different types of damages (delamination, void, cracks, scratch etc.) but also its positions. In most of the applications, a high voltage excitation (around few hundred Volts) is applied to the specimen. However, in some of the industrial applications, high voltage excitationmay not be preferred for safety reasons. One such example may include damage inspection in oil and gas tanks. To overcome this limitations, guided wave resonance based technique has been proposed in this study. If a continuous sinusoidal excitation is applied at the transmitter, then this guided wave would travel and reflect back from the edge of the sheet. This reflected signal will be superposed with the incident signal, which forms guided wave resonance. This resonance peak can be a good indicator for damage localization. If a wide range of frequencies excited at the input side, then it would result in resonance spectra which consists of multiple resonance peaks. Once these peaks are obtained, the corresponding time domain equivalent pulse propagation picture can be calculated by taking inverse Fourier transform (IFFT). From the time domain pulse propagation, damage location can be obtained. In this study, signal energy based algorithm has been applied which can locate the damage. Multiple transceiver pairs have been used to improve the damage location accuracy. In this work, aluminum sheet of dimension 610mm x 610mm x 3mm has been considered. Damage localization has been carried out for three different configurations in Aluminum sheet. This approach shows the possibility of damage detection in metallic sheets with good accuracy.

**Keywords:** Guided wave Resonance, Damage Localization, Ultrasonic Testing, Swept Frequency Acoustic Interferometry.





## Noncontact NDE: Flaw Detection in Metal Structure Using Nonlinear Ultrasonic Features

**CP 107** 

THE ABSTRACT

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Most NDE techniques involve contact-based measurement methods to collect data and extract related information. However, contact-based methods are still expensive, difficult to install at remote locations, require good contact between the sensor and test specimen, time-consuming to install, can interfere with the functionality of the structure, and produce results only at the locations where the sensors are attached. Air-coupled, noncontact ultrasonic techniquemay serve as an alternative to contact measurements. Commonly used techniques involve noncontact for sensing purpose only. However, for actuation also noncontact mode is very much needed for non-destructive ultrasonic examination of metal structures whileinspecting pipes, ships, and offshore constructions. With the continuous development of ultrasonic techniques, nonlinear features have been recently used for detecting of early damage in metals.

This study presents a noncontact sensing technique with ultrasonic wave propagation for flaw detection in a metal plate. Plate specimens ( $600 \square mm \times 300 \square mm \times 12 \square mm$ ) with two different notch depths(25% and 50% of plate thickness) are taken for the interpretation of notch defects. Through the plate, ultrasound pulses are transmitted from anair-coupled piezoelectric transducer at a particular angle of incidence and received on the same side (i.e. indirect mode of transmission). The nominal frequency of air-coupled transducers is 200kHz. Time and frequency domain analysisis performed on the received waveform to characterize the defects using indirect-transmission setup. It is observed that nonlinear ultrasonic features are sensitive to evaluate small size defects. Also, it was found that amplitude attenuation analysis can give some qualitative information about defects depth.

**Keywords:** Air-coupled ultrasound; non-destructive testing; indirect transmission; nonlinear ultrasonic.



# Wavelet Packet Transform-based Bridge Monitoring under Moving Loads using Limited Sensors

**CP 108** 

THE ABSTRACT

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Traditional vibration-based damage detection methods for bridge structures require dense sensor networks (which incur huge costs and are resource-intensive)to capture structural modal information and damage localization. These methods also depend on baseline response data from an undamaged state for comparisons, which limits their applicability for health monitoring of in-service bridges. This paper presents a baseline-free bridge monitoring approach with limited sensors based on wavelet analysis (wavelet packet transforms) of the bridge response under moving loads. The wavelet packet transform decomposes the bridge response signal into approximate(low-frequency) and detail(high-frequency) signal components. As the vehicle/moving load traverses a bridge crack, a singularity is created in the bridge time history responses at that time instant. The presence and spatial location of the damage are identified from the detail (high-frequency) signals. The common time instant of the singularity in the detail signals of the two sensors is used for damage localization. Numerical simulations have been carried out on a bridge model with damage simulated at varied locations and severities. The study also examines the influence of vehicle properties (vehicle frequencies greater or lesser than the bridge frequency) and rough profile on the efficiency of the proposed bridge monitoring approach. Investigations concluded that the proposed wavelet packet transform-based bridge monitoring approach could identify the spatial location of the damage using two sensors (one kept at mid-span) without apriori reference data. The results also demonstrate that the proposed wavelet packet transform-based diagnosis approach accurately locates bridge damage at different locations with different severity levels, even under higher surface roughness levels.

**Keywords:** Wavelet Packet Transform; Vehicle Bridge Interaction; Moving Loads; Damage Detection; Vibration Data





## Phase Coherence Imaging (PCI) of SS Cladding

CP 109

THE ABSTRACT

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Phase Coherence Imaging (PCI) is an advanced ultrasonic technique that usesphase information from Ascan to improve the visualization of defects in materials. PCI is an amplitude - free variation of TFM (Total Focusing Method). PCI uses FMC (Full Matrix Capture) data that is collected for the chosen wave set(s). PCI is less affected by attenuation in material since the frequency information is independent of amplitude. Hence it improves the UT performance in noisy materials or highly attenuating materials.

SS (Stainless Steel) material is a coarse grain, highly attenuating material. Conventional UT techniques face many challenges for flaw detection in SS material. In SS cladding process Ultrasonic testing is performed to detect under clad cracks (UCC) which are prone to exist in the interface of base metal and SS clad. Special probes designed for detection of UCC are used with conventional UT equipment. As SS is a coarse grain material and is of highly attenuating nature, high noise is seen during conventional UT which poses difficulty in detecting defects.

In this study, aa SS cladded platewith known defects is scanned with conventional UT and PCI. Also, the plate is radiographed with Iridium-192 source to visualize the defects. This comparative study on SS cladding gives a clear picture about the advantages in using PCI over conventional UT techniques. It has been observed that PCI has lower SNR compared to conventional UT. As PCI makes it easy to distinguish coherent areas, indicating the presence of defects, from incoherent areas corresponding to noisy areas of the image, lower SNR is not a drawback. The important features have been discussed in detail.

Keywords: Cladding, PCI, TFM, FMC, Ultrasonic Testing.



### Monitoring of Prestress Loss using Nonlinear Ultrasonic Methods

**CP 110** 

THE ABSTRACT

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Monitoring the stress-state in structuresis an ever-intriguing issue for ensuring the safety of structures. For determining the change in state-state, the ultrasonics-based non-destructive evaluation (NDE) methods have several advantages over the traditionalstress releasing methods. Concrete being highly heterogeneous material, exhibits anisotropic and also shows complex behaviorwhen change in stress takes place in such medium. In low stress levels (especially, below 30% of ultimate stress), stress-induced cracksmay not apparently form in the structure. However, the complex microstructure and inherent nonlinearity in concrete may inducethe growth of voids, microcracks, etc. which may lead to stress localization in the material. Again, for prestressed concrete structures (PSC), thecomplex configuration of the tendons imparts radial stress distribution to the embedding concrete. With time, such kind of stresses (including residual stress, local stress concentrations etc.) may initiate distressing condition to the structure. Application of efficient ultrasonic based NDE methods for stress monitoring of embedding concrete can provide a viable solution to overcome such real field problem.

The present experimentalinvestigation focuses on,(i) stress monitoring of a laboratory scaled prestressed concrete girder deck system using ultrasonic based methodologies, (ii) to develop efficient nonlinear ultrasonic methods (NLU) for monitoring prestressing losses. Ultrasonic investigation is followed in indirect transmission mode at mid-section of the girder. The response signals are analyzed with advanced NLU methods in frequency domain. The features of frequency spectra, such as, small side band peaks at either side of fundamental peak, presence of harmonics, the energy content of nonlinear peaks etc., reveal the presence of nonlinearity in the structure. NLU methods are highly efficient to track the changes in nonlinearity with the progression of prestressing force. A novel NLU method, namely, energy based nonlinear acoustic parameter (ENAP) is highly sensitive to monitor the prestress losses in the structure. The method has outperformed the traditional linear methods and harmonics based nonlinear SHG (super harmonic generation) method. The adopted NLU methods can efficiently be used to assess the stress variation and prestress lossesfor the prestressed concrete structures.

Keywords: Prestressed concrete, SHG, energy based nonlinear ultrasonics (ENAP), Stress monitoring





#### **Gamma-ray Computed Tomography System for NDE of Industrial Objects**

CP 111

THE ABSTRACT

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Gamma-ray computed tomography (CT) is essential for the non-destructive evaluation (NDE) of highdensity objects, where traditional X-ray CT falls short due to limitations in material density and radiation absorption. An in-house, first-generation monochromatic gamma-ray CT system has been developed. The transmission CT scanner utilizes a highly collimated gamma-ray source (137Cs 1.32 Ci) in combination with either a high-purity germanium (HPGe) detector (50% relative efficiency), or a more recently adopted cadmium zinc telluride (CZT) detector. The system includes a translation/rotation-based sample positioning setup, an 8K multichannel analyzer, and a dedicated data acquisition unit, all managed by custom-developed Visual Basic menu-driven software. This software automates precise CT movements and efficient data collection. Using this advanced gamma-ray CT system and an in-house developed Filter Back Projection CT reconstruction algorithm, numerous NDE studies have been successfully carried out. Some of the NDE Studies carried out using this system includes identification of embedded rebars in sealed stainless steel containers and concrete structures, 3D imaging of the internal structure of high volume air sampler towards reverse engineering, 3D reconstructions of a fuel pin within a closed container and idols showcasing its capability for high-resolution imaging of complex structures in dense materials. Recent results using a stainless steel phantom with the CZT detector demonstrate the system's ability to detect small features down to sub-millimetre scales, highlighting its potential for precise feature detection and material characterization. This in-house development at IGCAR showcases the potential of gamma-ray CT in advancing NDE techniques, effectively addressing limitations of conventional imaging and providing robust solutions in nuclear industrial imaging applications.

Keywords: Gamma-ray Computed Tomography (CT), , Non-destructive Evaluation (NDE), High-purity Cadmium Zinc Telluride (CZT) Detector, 3D Reconstruction, Nuclear, Germanium (HPGe) Detector, Industrial imaging Applications



#### DeFinder: Advanced Shearography Solution for Precise and Efficient Non-Destructive Testing of Composites and COPVs

**CP 112** 

THE ABSTRACT

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Optrion's DeFindershear ography system is an advanced solution for non-destructive testing (NDT) of highend composite materials and composite overwrapped pressure vessels (COPV). DeFinder provides precise defect detection, supported by proprietary algorithms and a user-friendly interface, delivering a reliable and automated inspection process ideal for industries such as aerospace, automotive, and energy. Fully developed in-house, DeFinder's software enables seamless configuration, monitoring, and customization to meet specific testing needs.

A key advantage of DeFinder is its innovative laser light source, utilizing a Single Longitudinal Mode laser with a top-hat beam projection to ensure uniform light intensity and phase stability across surfaces. Combined with the system's interchangeable front lenses, this setup offers an adaptable field of view, optimized coverage for diverse part shapes and sizes, and minimized underexposure – enhancing defect visibility. DeFinder's advanced image processing includes proprietary phase unwrapping and Time Sequence Compression (TSC), enhancing defect visualization by minimizing data loss and compressing image sequences to streamline analysis and data storage.

In addition to standard image processing, DeFinder now includes advanced capabilities to precisely detect, locate, and measure defects. Operators can view detailed parameters, such as defect size and contrast-to-noise ratio, significantly improving analysis accuracy. DeFinder's software includes an automated scripting capability, allowing operators to standardize testing parameters, making it especially valuable in high-volume or less skilled labor environments. Integrated temperature and distance monitoring further ensures consistent inspection conditions, while the "Scene View" feature overlays high-definition images with inspection results, enabling precise defect localization.

With seamless integration into robotic systems, DeFinder enhances automation, accelerates inspection cycles, and improves reliability in quality assurance, all while reducing reliance on highly skilled operators. This adaptable, cost-effective solution offers the precision and flexibility required to meet rigorous NDT standards in high-performance sectors.

**Keywords:** shearography, COPV, NDT, robotic system, composite





### Automatic X-Ray Based PHWR Fuel Pin Scanning System

**CP 114** 

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THE ABSTRACT

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Pressurized Heavy Water Reactors (PHWR) fuel consists of either 19 or 37 numbers of fuel pins held together by endplates in a concentric configuration. Each fuel pin consists of a stack of natural uranium dioxide (UO2) pellets, encapsulated in cylindrical thin wall tubes made from zirconium alloy. UO2 pellet stack inside the fuel pin has to meet stringent length requirements failing which can lead to premature fuel failure in the reactor. X-ray based detection forms the confirmatory test for ensuring completeness of pellet stack during fuel fabrication. In order to facilitate high throughput and man-less operation, a dual energy X-Ray based automatic fuel pin scanning system has been designed, developed and deployed for use in shop floor at Nuclear Fuel Complex, to detect an incomplete pellet stack viz. missing pellets. The system utilizes dual energy X-Ray based material discrimination algorithm that separates materials with different effective atomic number and adds color-coding as per material composition. Missing pellet anomaly detection comprises of fuel pin segmentation algorithm to delineate the individual fuel pin, followed by missing pellet localization mechanism. The fuel pin segmentation involves binarizing the scanned image which is then subjected to Marching Squares algorithm to extract iso-contours from a 2D scalar field to contour individual fuel pins. In case of detection of an incomplete pellet stack the missing pellet area localization is carried out and an audio-visual alarm is generated if total missing length exceeds a defined limit. The X-Ray image of the fuel pin is also archived in the system along with the identification tag for historical data and report generation.

**Keywords:** Dual energy X-Ray imaging, UO2 fuel pellet stack, Material discrimination, Missing pellet anomaly detection



#### Mapping of Brittle Failure of A Composite Structure using Acoustic Emission Technique

**CP 115** 

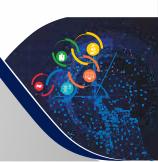
THE ABSTRACT

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Carbon fiber reinforced polymer (CFRP) composite structures are widely used in satellite launch vehicles due to their high stiffness and specific strength. A CFRP structure can fail due to design flaws, poor workmanship, inappropriate loading, improper fabrication process and inappropriate inspection tools. A structural qualification test of a newly designed structure is carried out to verify and validate all the above process including design. However, during testing, a composite structure can fail very instantaneously without providing any evidences for the reason of failure or failure location. Such failure is characterized by no warning signs, no gradual degradation, and sudden loss of structural integrity. Instrumentation like strain gauges and displacement transducers fail to capture such instant structural degradation. In this paper, authors report the use of acoustic emission technique in mapping the instant brittle failure of a composite hardware during structural testing. Acoustic emission is a technique which records surface deformation in the order of pico-meter due to stress waves generated during micro level material activities at a rate of 10000 mega samples per second. In a composite structure fiber matrix de-cohesion, micro buckling, matrix shears etc, are sources of acoustic emissions. Usually in composites the damages will spread throughout the structure which make it difficult to identify the source point of failure initiation. Through proper design of AE sensor layout based on the attenuation characteristics and using proper analysis methodology the nature and location of failure can be determined even during such instant brittle failures. The load upto which the integrity of the structure holds good also can be evaluated through acoustic emission data. In this paper the characteristics of the AE signals recorded during the failure time and the methodology followed to identify the source location of failure are presented along with the evaluation criteria used in identifying the possible nature of failure of the composite structure. The sensitivity of various AE parameters during the failure instance is also illustrated in this paper

**Keywords:** Acoustic Emission (AE) technique, brittle failure, protective coating, crack growth, amplitude, energy, counts





### Automation of Processing of X-ray Films for Radiography of Solid Propellant Motors

**CP 116** 

THE ABSTRACT

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Radiography testing of launch vehicles components are carried out to detect defects in order to ensure their integrity. In radiography testing, the exposed X-Ray films are processed in darkrooms either by manual method or using automatic film processors. In aerospace NDT, the radiographs need to be of high quality to reveal the finer defects as space systems demands high reliability. Missing or misinterpretation of critical defects of a single component may lead to the failure of the entire mission.

In commercially available automatic film processors, the X-ray films are fed though a number of roller pairs which cast roller impressions on the films. If such roller marks fall exactly on the defect indication, it may go unnoticed or appear as fainter indications leading to their omissions. Hence, such systems are not suitable for small to medium sized solid rocket motors in which critical defects like propellant cracks and separation at the interfaces will become difficult to discern.

Hence, these films are currently processed manually using conventional chemical processing method called tank processing. In this method, X-Ray films are processed by immersing them in different chemical baths for prescribed time with proper agitation. This is a strenuous job as it is to be done in darkroom environment by hand movement of the operator. It is a skilled job and hence the radiograph quality is fully operator dependent. The consistency in quality is affected by operator fatigue resulting in processing marks leading to re-takes. Hence, an attempt is made here to develop a system for replacing the manual film processing by automating the entire processing operations without compromising the quality.

In this study, the films are processed by circulating the chemicals around the films through a pipe system which is immersed in the processing baths. There will be two sets of pipes having multiple orifices for inlet and outlet system and by regulating the flow, a uniform flow will be established in the bath. In this study, direction of flows, diameter of pipes, interleaving spaces, orifice dia, etc. where varied and optimised to get the desired results. Shifting of films from bath to bath are carried out using an automated arm mechanism. Trials are conducted successfully and the radiographs obtained were of the desired quality that was comparable with manually processed radiographs.

**Keywords:** Radiography testing, X-ray films, space systems, solid propellant, film processing



### Characterization of Ultrasonic Test Signals for Inspection of PHWR Fuel End Cap Welds

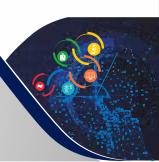
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THE ABSTRACT

Pressurized Heavy Water Reactors (PHWR) form the core of India's first stage in its Nuclear Power Programme. Each 220 Mega Watt PHWR fuel bundle contains 38 resistance-welded end cap welds, while each 540/700 Mega Watt PHWR fuel bundle has 74 such welds. Any weld failure could lead to the release of fission products into the primary heat transfer circuit and allow coolant water to enter the fuel pin, ultimately resulting in the failure of the fuel bundle. The customer specification mandates 100% ultrasonic inspection of these welds. The end cap welds of PHWR fuel pins are tested ultrasonically on 100% basis by using immersion shear wave technique on automated machines. Providing real-time feedback to the end cap welding operators is crucial for maintaining high recovery rates and ensuring weld quality standards are met. In addition to rejections caused by defect amplitudes exceeding the threshold limit, it is essential to analyze various UT signals to characterize weld flaws, monitor echoes that indicates deviations from optimal weld conditions, and identify false rejections. Moreover, precise control of the probe scanning distance is necessary to prevent signals from the weld's outer upset from entering the flaw gate region. This necessitates frequent operator intervention to adjust the initial scanning point as the length of the fuel pins can vary. As a result, it demands highly skilled inspectors and is a time-consuming process. This paper outlines the various defects encountered during end closure welding and the current ultrasonic testing (UT) process. It also discusses the developed methodologies aimed at automating the manual signal interpretationand feedback process, thereby reducing false rejections without compromising inspection throughput.

Keywords: PHWR, Endcap weld, Ultrasonic, Characterization, Nuclear, Automation





# Automation of ID visual inspection of 30m long Alloy 800 steam generator (SG) tubes for 700 MWe PHWRs At Nuclear Fuel Complex, Hyderabad

**CP 118** 

THE ABSTRACT

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Alloy 800 Steam Generator tubes of around 30m length for 700 MWe Pressurised Heavy Water Reactors (PHWRs) is being manufactured at NFC through hot working and cold working operations like Pilgering, Annealing etc... These tubes are further U-bent into 72 different radii after qualifying in various NDT tests. As the SG tubes are Class-I component and act as boundary between radioactive primary water and secondary water, the integrity of these tubes is very important. So, SG tubes prior to bending are subjected to various Non-Destructive Tests like Ultrasonic Testing, Eddy Current Testing& visual inspection from both OD and ID side.

ID visual examination is one of the NDT inspection that is being carried out for these tubes where 100 % of tubes are to be inspected for full length of around 30m to ensure that the ID surface is free from surface defects. Each SG set consists of around 2500 no's of such tubes.

The conventional ID visual inspection system used for the above inspection consists of a camera connected to a cable of 30m length and the camera output is connected to a display. The operator will take the decision based on the video output on the display.

In the conventional setup the operator has to push the 30 m length cable inside the tube and simultaneously has to inspect the tube internal surface on the monitor for any abnormal surface features. After completing the inspection the 30m length cable has to be taken back and wound on the cable drum. This is a very tiresome & time consuming operation which can lead to higher operator fatigue, lower output and reduced concentration of the operator. In addition to the above the inspection speed is not controlled between the cable pushing movement strokes and assessing the inspection capability for detecting the smallest indication is difficult.

To overcome the above mentioned challenges, an automated system was developed and implemented. The developed system has increased the inspection rate by more than 50%. This paper explains the methodology and the system developed in detail. It also highlights various practical studies carried out for arriving at the inspection speed, magnification, assessing smallest indication that can be detected etc...

The automated system was analysed and compared with conventional system w.r.t indication detection and shift throughput.

**Keywords:** Alloy 800, SG tubes, ID visual inspection, Borescope inspection.



### Finite Element Simulation of Ultrasonic Wave Propagation in Anisotropic Austenitic Stainless Steel Weldments

**CP 119** 

THE ABSTRACT

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Ultrasonic testing is a popular non-destructive evaluation (NDE) technique, particularly in safety-critical industries where weld integrity is crucial. Austenitic stainless steel (ASS) weldments exhibit anisotropy due to their complex microstructure such as elongated columnar and inhomogeneous grain structure. This anisotropy in ASS weldments is the cause for widely known phenomena such as beam skewing and splitting, which distorts the propagating ultrasonic waves in the ASS weldments, complicating the analysis and interpretation of the ultrasonic signals, thereby resulting in inaccurate identification and characterization of defects—particularly concerning in industries where structural integrity is essential.

In the present work, various finite element method (FEM) simulation models are developed and tested to understand the ultrasonic wave propagation behaviour in ASS parent material and anisotropic ASS weldments. In order to accurately simulate the FEM models, realistic weld domain orientations are used in the present study, which are derived from Electron Backscatter Diffraction (EBSD) studieson ASS weldments. FEM models are developed for different phased array ultrasonic testing (PAUT) techniques, which include Full Matrix Capture-Total Focusing Method (FMC-TFM), Plane Wave Imaging (PWI-TFM), and through transmission angle-dependent ultrasonic velocity measurements. The developed FEM models are validated by comparing the FEM results with the experimentally measured data on ASS parent material and weld samples with calibration defects. Additionally, these results are compared against those obtained through CIVA simulation software to enhance reliability and verify model accuracy. This comprehensive approach provides valuable insights into ultrasonic wave behavior in anisotropic weldments, contributing to improved NDE practices in challenging weld materials.

**Keywords:** austenitic stainless steel weld,ultrasonic wave propagation, anisotropy, PAUT angle-dependent ultrasonic velocity, finite element method





# Development of High Frequency Guided Wave based Methodology for Inspection of Drywell Liner Vessel of Boiling Water Reactor

**CP 121** 

THE ABSTRACT

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In a boiling water reactor (BWR), the primary containment system consists of a drywell liner vessel, which is an important engineering structure that acts as the final barrier in preventing the release of fission products in the event of an accident. To ensure the structural capability and leak-tight integrity of the containment, the drywell steel liner must be inspected periodicallyfor early detection of any damage to the liner. In a BWR, the drywell steel liner is located in the inaccessible region between the concrete and sand cushion zone and is particularly vulnerable to corrosion damage caused by environmental conditions or ageing. Therefore, an NDT methodology needs to be developed with the objective of inspecting the critical and inaccessible regions of a BWR nuclear power plant's drywell steel liner.

A novel high-frequency guided wave-based methodology was developed to inspect the inaccessible regions of the containment drywell liner vessel using ultrasonic high-frequency guided waves (HFGW). The potential of this methodology was demonstrated on a steel calibration plate with different types of artificial defects resembling typical corrosion damage in a drywell steel liner vessel. A 4 MHz commercial piezoelectric ultrasonic transducer along with a 70° angle wedge was used to generate the HFGW in the plate. It was observed that the HFGW was less dispersive and capable of propagating over a range of the required scan distance (400 mm) and witha required defect detection sensitivity of 10% wall thickness defects. A discussion of the potential application of this methodology in commercial nuclear power plants is presented in this work.

**Keywords:** Boiling water reactor, drywell liner vessel, high-frequency guided waves, corrosion damage



# Scalable Deep Learning Model for Detecting and Classifying Welding Defects in Radiographic Images of Pressurized Cylindrical Welds.

**CP 122** 

THE ABSTRACT

The detection and localization of welding defects in radiographic images are crucial for maintaining the safety and integrity of welds in Pressurized pipe/tubes, which are used in various industrial applications. Ensuring that these welds are defect-free is essential to prevent failures that could lead to productivity& revenue loss. This research introduces a transfer learning &deep learning-based approach specifically designed to effectively detect, locate, and classify welding defects in radiographic images targeting weld joints in pressure parts.

The core of this approach lies in fine-tuning generic object detection models using domain-specific data. By doing so, the models become highly adaptable to a range of operational contexts. This adaptability is achieved through dataset adjustments, allowing scalability across different use cases, from small-scale operations to large industrial applications. The study highlights the importance of optimized hyperparameters, which are key to enhancing the model's accuracy and reliability in defect detection. Moreover, the research delves into model quantization techniques within deep learning frameworks. These techniques are essential for reducing computational costs without sacrificing performance, thereby improving throughput. This innovation makes the proposed solution not only highly accurate but also scalable and cost-effective. As a result, it emerges as an exemplary method for defect detection in industries where quality control is critical.

Further, this techniques has the potential to the address current challenges and provide a solution to reduce the issue of human error, reduce the interpretation time, reduce down time of power plants in boiler tube failures.

Key Area for Industrial Application: Power Sector, Oil & Gas Industries, Liquid &Gas Processing Systems, Defence Sector, Manufacturing & Assembly line Quality Control & etc.





# Application of Automated inspection using Phased Array Ultrasonics for the Assessment of Weld joints of Aluminium alloy Propellant tanks of Satellite Launch Vehicles

**CP 123** 

THE ABSTRACT

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One of the Indian launch vehicles employs Aluminum alloy make propellant tanks in its upper stage for its relaxed payload missions for the storage of fuel and oxidizer during the flight operations. These propellant tanks are realized from Aluminium Alloy (AA2219) rings and domes and consists of five circular seam weld joints and two manhole cover weld joints. As the tanks handle hypergolic propellants, integrity of the weld joints is very important as failure of the samewill lead to total mission failure.

Automated Gas Tungsten Arc Welding (GTAW) process is adopted for all the weld joints in the tank.NDE for the integrity assessment of weld joints is very critical and mandates Liquid Penetrant Testing (LPT), Ultrasonic Testing and X- Ray Radiography followed by proof pressure testing. The conventional monocrystal UT using shear waves of 600& 700 was employed initially for the assessment of circular seam welds in addition to Radiography and LPT. Conventional UT requires real-time interpretation and no permanent record of ultrasonic test data will be available for future. Moreover, it takes at least one day to complete the UT inspection of one weld joint and five days for one such tank having five circular seam weld joints.

It was anticipated that the unique capabilities of PAUT to steer and focus the Ultrasonic beam could enhance data acquisition for reliable flaw detection in the weld joints. Considering the large inspection time taken for the 100% inspection of the weld joints, it was proposed to automate the whole process of PAUT data acquisition. The automated PAUT facilitates better data acquisition and ease the interpretation process thereby hastens the rate of UT inspection to one tank per day.

In the process, atest set up for the PAUT inspection of the tank is established by design and fabrication of scanning fixtures and customized probe holding attachment which can hold two PA probes and an encoder simultaneously. Tank was held in the horizontal turning centre and rotated in a uniform speed. PAUT data acquisition was done from the both sides of the weld using Olympus Omniscan MX2 PAUT system and probe holding attachment. Results of automated PAUT were compared with conventional UT & Radiography for validation.

This paper describes the details of development and results of automated PAUT testing of typical Aluminum alloy (AA2219) propellant tank used in the upper stage of aSatellite Launch vehicle.

Keywords: Automated PAUT, Non-Destructive Evaluation (NDE), Conventional Ultrasonic Testing.



#### **NDE Using Drone**

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CP 124
THE ABSTRACT

In the realm of Non-Destructive Evaluation (NDE), Unmanned Aerial Vehicles (UAVs), commonly referred to as drones, represent the forefront of innovative solutions aimed at enhancing safety and operational efficiency. These drones are outfitted with advanced equipment such as high-resolution visual cameras, thermal sensors, ultrasonic thickness gauges, and pressure washing capabilities. They serve a multitude of purposes, spanning from visual and thermal inspections to obtaining thickness measurements of tanks, and even facilitating the cleaning of intricately positioned structures. Drones have proven instrumental in substantially enhancing safety and expediting NDE work processes.

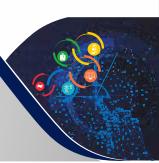
Conventional Non-Destructive Testing (NDT) techniques, typically employed in elevated settings, necessitate the erection of scaffolding, a process known for its safety hazards, sluggishness, and substantial capital investment. Consequently, elevated, and hard-to-reach areas are left without continuous monitoring due to the intricacies involved, safety considerations, and the significant costs associated with scaffold preparation. This has posed a critical challenge for asset owners who must contend with the constant risk of failures.

Modern industrial aerial platforms are ideally suited for addressing these issues. Drones have the ability to ascend several hundred meters in mere minutes and eliminate the need to jeopardize human lives. Conducting visual and thermal inspections becomes exceptionally efficient, as drones effortlessly reach otherwise inaccessible areas. The safety and efficiency in utilizing drones for the purposes of structural cleaning and thickness measurement make them the preeminent choice for industrial stakeholders.

As a result, the adoption of drone-based inspection methods significantly incentivizes the asset owners to embrace this innovative approach to Non-Destructive Evaluation (NDE). This transition yields substantial cost savings, eliminates safety apprehensions, expedites the assessment process, and enables more frequent inspections to safeguard and maintain the integrity of their assets.

Keywords: Drone, UAV, Ultrasonic, Thickness, Thermal imaging, Visual





# Feasibility of Monitoring Bond Integrity in GFRP-Concrete Members UsingImpedance-Based Monitoring Systems: A Novel Power Spectral Based Approach

**CP 126** 

THE ABSTRACT

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The increasing utilization of glass fiber-reinforced polymer (GFRP) and concrete composite systems in civil and structural applications is critical for the long-term performance of reinforced elements. Precise monitoring and assessment of bond integrity at various loading stages are important for ensuring optimal performance and safety. Electromechanical Impedance (EMI) based monitoring of bond integrity gathers substantial interest and is able to detect subtle changes through different damage-sensitive EMI parameters. However, the reliability of these parameters is qualitative in nature, posing challenges in capturing sensitive features, i.e., damage identification, localization, and early prediction of critical damage. In this article, an EMI based approach via piezo sensor has been proposed for monitoring thebond integrity processes at the GFRP-concrete interface in GFRP-concrete composite elements. First, pullout testing has been conducted as per RILEM recommendations in a controlled loading environment to validate the EMI approach. Then, the study evaluated the progressive degradation of bond stress through piezo-coupled conductance signatures. The results show a clear correlation between the shifting of peak frequency and the progressive weakening of bond degradation. Statisticalindices have been applied to quantify the severity of micro-level changes occurring at the interface. Furthermore, the power spectra entropy (PSE) features have been employed to evaluate the wave energy distribution characteristics of the signal distinctly for different stages of bond integrity damages. The finding of the results reveals that spectral entropy shifts under different phases of interfacial stress and degradation. The PSE feature enables a more precise investigation of the frequency content of EMI, apprehending small deviations in EMI characteristics that correspond to varying levels of bond integrity. In summary, the findings of this research underscore the use of EMI-PSE features for bond integrity monitoring of GFRP-concrete composite in modernday infrastructure systems.

**Keywords:** Impedance, Concrete, Power Spectral Density (PSD), Damage Localization, Bond Integrity, Glass Fibre Reinforced Polymer



#### Enhanced Subwavelength Ultrasonic Imaging with Structured Channel Metalenses and Array Transducers

**CP 128** 

THE ABSTRACT

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Structured channel metalenses (SCM) hold substantial promise for super-resolution imaging, particularly within non-destructive evaluation (NDE) where capturing detailed subsurface defect information is critical. Subwavelength imaging has traditionally relied on through-transmission configurations, with slits or point sources commonly used as targets in optical and acoustic domains. However, non-destructive evaluation (NDE) settings often require pulse-echo techniques due to limited access to one side of the material. This study introduces a novel techniqueto image subsurface defects in metallic samples using conventional narrow-band phased array probes in combination with Structured Channel Metalens (SCM), whose dimensions are optimized using numerical simulations. This approach enables imaging of subwavelength features by enhancing evanescent waves which is applicable in both pulse-echo and through-transmission modes. In our finite element models, ultrasonic waves are modeled as impinging normally on side-drilled holes in metallic samples and pass through SCM across both pulse-echo and through-transmission configurations, generating a detailed response for subsurface feature detection of subwavelength dimensions. At the receiver end, line-scan images are generated basedon waves captured according to the pitch of commercially available array ultrasonic probes. The simulations are validated with experiments conducted in a similar fashion in both configurations. From our studies, we present the results and draw conclusions on the potential applications and future directions of this technique in NDE. Thus, the implications for SCM-enhanced phased array systems in NDE suggest significant future scope for this imaging technique, addressing both practical limitations and performance demands.

**Keywords:** sub-wavelength imaging, metamaterial, periodic holey structures, Rayleigh diffraction limitation, Phased array ultrasonics





### Enhancing SNR in Bulk Wave EMATs Through Concentrated Static Magnetic Field in Eddy Current Regions

**CP 129** 

THE ABSTRACT

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This study introduces advancements in electromagnetic acoustic transducers (EMATs) designed to generate ultrasonic bulk waves, encompassing both shear and longitudinal waves, for inspecting metallic materials. EMATs are critical in non-destructive testing as they facilitate the examination of materials without direct contact, preserving the integrity of the materials. Despite their substantial benefits, the utility of EMATs is frequently constrained by a low Signal-to-Noise Ratio (SNR). This research aims to augment the Lorentz force and the generation of ultrasonic waves through the optimization of magnetic field concentration in regions where eddy currents are induced. Finite Element (FE) simulations were carried out on aluminum samples to assess the influence of different liftoff distances and to underscore the critical role of intensifying the static magnetic field within the eddy current areas. Insights from these simulations informed the design of various EMAT configurations that improve the magnetic field concentration in the eddy currentgenerating regions. These new configurations were tested to measure the thickness of aluminum samples at 26 mm and 50 mm. The improved configurations exhibited an enhanced SNR, demonstrating greater efficacy for complex industrial applications and underscoring their potential for broader industry adoption. This enhancement in SNR not only extends the applicability of EMATs in industrial settings but also increases the reliability of measurements and inspections carried out with these devices. By successfully focusing the magnetic field more precisely in the critical regions, these EMAT configurations can provide more accurate and reliable data, which is paramount in industrial quality control and safety assessments. This research represents a significant step forward in the application of EMAT technology in non-destructive testing, indicating a promising future for these transducers in enhancing industrial processes and ensuring material safety with greater precision and effectiveness.

Keywords: Permanent magnet EMAT, Bulk waves, Signal-to-Noise Ratio (SNR), Lorentz force.



### In-situ process Monitoring of Newtonian Fluids Using a Portable Ultrasound Viscosity Sensor

**CP 131** 

THE ABSTRACT

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This work demonstrates that a single calibration equation linking the ultrasound signal with the fluid viscosity and density can measure fluid properties across multiple Newtonian fluids. The ultrasound waveguide provides a constant strain rate, provided the frequency and amplitude are constant. The oscillation frequency is higher in ultrasound when compared to a conventional viscometer or rheometer with a rotating spindle. However, by definition of a Newtonian fluid, irrespective of a high or low strain rate applied to the fluid, the shear stress thus developed adjusts to result in a constant viscosity. Thus, in the present work, we demonstrate that the viscosity of Newtonian fluid measured using a high strain rate or ultrasound matches the measurement done using conventional instruments with a low strain rate applied to the fluid. The shear stress developed at the boundary of the fluid and the torsion waveguide depends on the relative values of the shear impedance (Zf) of the fluid and the solid waveguide (Zs) and is reflected as a signal amplitude change. The shear impedance is directly proportional to the square root of fluid shear viscosity and the fluid density. In the present work, we demonstrate that using a single calibration equation, the properties of different Newtonian fluids are measured using a torsion waveguide. Our experimental results showcase viscosity measurements that are both repeatable and accurate to within one centipoise. The reliable measurement of any random Newtonian fluid using a single calibration equation extends the capability of the ultrasound waveguide sensor to be used as a dipstick sensor across multiple industries. The potential industrial application is the food sector and other manufacturing processes involving Newtonian fluid.





# Application Of Extreme Learning Machine (ELM) Algorithm for Predicting LifeExpectancy of Concrete Structures Using Non-Destructive Test Results: A Comparative Study

**CP 132** 

THE ABSTRACT

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Corrosion-induced degradation in reinforced concrete(RC)structures poses a severe problem, which lowersits service life and enhances safety and maintenance costs. Conventional techniques for assessing the influence of corrosion on concrete life are generally laborious, costly, and inaccurate due to complicated environmental circumstances. The advent of artificial intelligence has enabled the development of robustpredictivealgorithms that provide a more effective, Fast, accurate, and precise evaluation of concrete life in extreme conditions. In contrast, this study aims to propose three different algorithms, i.e., support vector machine (SVM), artificial neural network (ANN), and extreme learning machine (ELM) algorithms, for the prediction of the life expectancy of concreteusing 220 numbers of datasets conducted in the laboratory environments. The datasets consist of a spectrum of input variables, such as days of corrosion, half-cell potential values, pH, and concentration, affecting the output variables, such as mass loss. Various performance metrics have been employed to validate the efficacy of proposed predictive models. The result of this study shows that the ELM model is capable of reaching superior performance (Accuracy 95%) compared to the other two models. The superior predicting ability of the ELM model is mainly due to complex nonlinear mapping, which allows it to capture complex patterns efficiently and avoid overfitting. In summary, the findings of this research demonstrate the significance of the ELM model in evaluating the mass loss of concrete. The present study exhibits the potential of the proposed ELM algorithm to enable a faster training process to predict the life of RC structures by improving the structural safety, durability, and reliability of infrastructure systems.

**Keywords:** Concrete, Corrosion, Non-Destructive Testing, Extreme Learning Machine (ELM), Support Vector Machine (SVM), Artificial Neural Network (ANN)



#### Development of a Noise-Based Passive Structural Health Monitoring System for Composite Structure

**CP 133** 

THE ABSTRACT

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Passive structural health monitoring (SHM) systems face a challenge in achieving control over the propagating noise field, thereby limiting their application towards defect identification and localization. To overcome this an outlier-based statistical technique is applied here to achieve defect detection independent of the input perturbations. The proposed technique is validated using an experimental setup based on an air blower as the noise source and performing a cross-correlation between the out-of-plane displacement data measured at different locations of an Aluminium sample. The results show the feasibility of defect detection using the sparse sampling-based outlier analysis in a passive SHM system that can effectively assess the structural health integrity of infrastructures deployed under harsh environmental conditions with limited access to power sources. Another objective of my work is to develop passive, noisebased SHM techniques for composite materials by using Piezoelectric Transducer (PZT) and Fiber Bragg Grating (FBG) sensors to capture the diffused wave field within the composite structure. Cross-correlation was performed between the out-of-plane displacement data obtained from the GFRP sample at two different locations. The results demonstrated a good correlation between the two locations, which was validated using active wave propagation. This study highlights the effectiveness of the passive ambient noise cross-correlation technique for SHM, highlighting its potential in retrieving the Green's function with PZT and FBG sensors. However, challenges remain in achieving uniform wave field distribution and maintaining consistent frequency with minimal fluctuation. This research contributes to the development of a passive SHM system capable of efficiently evaluating the structural integrity of composite structures under challenging environmental conditions with limited power supply.

**Keywords:** Passive Structural Health Monitoring, Defect identification, Ambient Noise, Piezoelectric transducer, 2-Dimensional Fast Fourier Transform (2-DFFT), Wavenumber Analysis. Piezoelectric transducer, FBG Sensor, GFRP





### Study and Comparison of Different Staggered EMATconfiguration to Generate Ultrasonic Guided Wave in Pipe Structures

**CP 134** 

THE ABSTRACT

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Electromagnetic Acoustic Transducers are the non-contact type of transducers that are used for the generation of various types of ultrasonic waves based on the Lorentz force principle. For the generation of the shear horizontal and torsional guided waves, periodic permanent magnet (PPM) EMAT is a configuration in which two consecutive magnets are oriented in opposite direction. An advancement over PPM EMAT is Halbach EMAT where the magnets are arranged in such a way that the bias magnetic field in one direction is very high compared to another which results in high signal-to-noise ratio. As a specific case of PPM and Halbach EMAT, Staggered EMAT introduces a lateral movement in the magnet rows so that the wave propagation occurs at an angle.

This research investigates the application of Staggered Electromagnetic Acoustic Transducer (EMAT), mainly focusing on the beam steering capabilities of Guided Wavesin pipe structures. A three-dimensional model of double row Staggered PPM and Halbach EMAT is developed and a finite element analysis is carried out in an aluminium pipe with high radius to thickness ratio. For all the configurations, the total displacement is studied keeping the wavelength of the transducer constant. The corresponding frequency is derived from the dispersion curve. The study analyses Staggered PPM and HalbachEMATs where the second row of magnets is displaced by the maximum value of half of the wavelength for both. The interference between the waves generated from the two magnet rowsresulted in the directivity change of the guided wave. The finding of this study shows the enhanced beam steering capabilities of Staggered EMATs, particularly in the field of pipeline monitoring and can lead to more precise and effective detection of structural defects.

**Keywords:** Staggered EMAT, Beam Steering, Guided Wave, Pipeline Inspection



## Development of Phased Array Ultrasonic Inspection Methodology for Inspecting Keyways in the Turbine Rotor Wheel Hubs

**CP 135** 

THE ABSTRACT

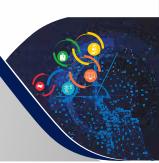
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Turbine rotors are one of the key components in a nuclear power plant and are subjected to harsh operating circumstances, including high rotating speeds, pressures, and temperatures. The replacement of turbine rotors is challenging, time-consuming, and expensive. Hence stringent turbine rotor quality control and management is followed to ensurethe proper maintenanceof rotor parts, extending rotor life and reducing the need for costly repairs or replacements. As part of this, periodic inspections are carried out to detect damage indicators like material fatigue, corrosion, or cracks in the turbine rotors. Keyway regions of the turbine rotors are identified as one of the high-probable locations for crack initiation and failure. Due to limited access and complicated geometry of the keyways of the rotor, conventional ultrasonic inspection is difficult to perform and necessitates the development of advanced ultrasonic inspection methodology for early detection of cracks in the keyways, which enables to estimate of the remaining life assessment of the turbine rotor. To overcome the above-mentioned limitation, an advanced phased array ultrasonic technique (PAUT)was developed to inspect and characterise the flaws, if any present, in the keyway region of the turbine rotor, where the inspection is carried out from the wheel hub and web regions of the rotor.

In the present study, PAUT methodology was developed to inspect the keyway region of the turbine rotor using a 10 MHz 128 elements 0.25 mm pitch phased array ultrasonic transducer. Multiple calibration blocks with artificial reference planar defects (simulating tight cracks) were machined at various locations/depths in the keyway region of the turbine rotor and used to develop and demonstrate the efficacy of the PAUT methodology in inspecting the turbine rotor's keyway regions. The experimental results on these reference EDM notches in the calibration blocks were presented.

Keywords: PAUT, phased array ultrasonic testing, turbine, rotor, keyway and wheel hub.





#### Nonlinear Ultrasonic Wave Mixing Technique for Detecting Micro-Damage Evolution in Concrete

**CP 136** 

THE ABSTRACT

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Early detection of closed cracks is critical to ensuring structural safety and durability. Detecting these cracks at a micro level can help prevent the propagation of damage and lead to safer structures. Therefore, it's crucial to use more sensitive nondestructive evaluation techniques for detecting internal micro-cracks within concrete. While ultrasound is widely used in non-destructive testing (NDT) of materials, conventional ultrasonic methods are typically more responsive to open cracks and frequently fail to identify closed cracks. Due to their close contact, closed cracks are difficult to identify, allowing micro-damage to go undetected until it progresses to more severe forms of degradation.

Nonlinear ultrasonic wave mixing has proven to be a sensitive method for identifying and characterizing closed cracks by utilizing harmonic generation and nonlinear resonance. The nonlinearity considered in the present study is due to crack wave interaction, known as breathing cracks, which leads to contact acoustic nonlinearity. A pump-and-probe wave intersection method is proposed in this study to monitor the development of micro-damage in notched concrete beams. When exposed to three-point bending, a central notch in the beams allows for controlled crack initiation and propagation. The results show that this dual-frequency wave mixing technique is a dependable tool for early detection and real-time monitoring of infrastructure damage since it successfully captures nonlinear responses from closed cracks. Furthermore, the results from nonlinear ultrasonic wave mixing correlate with acoustic emission techniques, providing additional insight into damage progression in concrete. This method has great potential for improving structural health monitoring and extending the service life of concrete-based industrial structures.

Keywords: Non-destructive testing (NDT), Micro-damaged etection, Concrete structures.



### In-situ Phased Array Ultrasonic Evaluation for characterizing Solid-Liquid Interface during Continuous Casting of Steel

**CP 137** 

THE ABSTRACT

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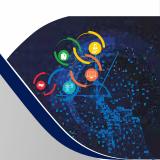
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In this research work, phased array ultrasonic testing method is used for detecting the location of solidliquid interface when steel is being casted in continuous casting process. The knowledge of solid-liquid interface during continuous casting process can help in controlling the production rate and process parameters. The phased array ultrasonic imaging uses Full Matrix Capture algorithm to acquire the ultrasonic A-scan data from the steel when it is solidifying from very high temperature and just came out of caster. Total Focusing Method uses this elementary A-scan data and plot a two-dimensional image in distance domain where location of solid-liquid interface can be seen. The phased array ultrasonic probe is protected from direct contact with high temperature steel surface. The Alumina and Stainless-Steel Plates are used as a wear cap between probe and solidifying steel slab. Finite Element simulations and experiments are performed to get the optimum thickness of wear cap plates to have maximum time of contact of probe assembly with solidifying steel. Effect of thickness of wear cap plates on ultrasound and its effects on accurate location of solid-liquid interface are also studied. Finite Element Models are created to replicate the heated steel having a temperature gradient and the dynamic loading is used to generate ultrasonic bulk waves in the specimen. The research focuses on increasing the rate of production of Steel manufacturing industries by providing the visual insights of steel at an elevated temperatures during continuous casting process.

**Keywords:** Phased Array Ultrasonic Imaging, PAUT, Full Matrix Capture (FMC), Total Focusing Method (TFM), Continuous Casting, Solidifying Steel, Solid-Liquid Interface.





THE ABSTRACT

### Guided Wave Phased Array Imaging for Thin Plate Inspection Using Full Matrix Capture and Virtual Array Source Aperture

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This study focuses on the application of phased array ultrasonic testing with guided waves for Structural Health Monitoring (SHM) of thin plates. Addressing the limitations of conventional ultrasonic testing efficiently by inspecting thin, long structures. Guided wave techniques, particularly using Lamb waves, are highly effective for thin plate inspection, providing long-range non-destructive evaluation. In this Research, a phased array setup operating at 2.25 MHz was utilized to assess the performance of Full Matrix Capture (FMC) and the Virtual Array Source Aperture (VASA) for enhancing defect detection in thin plates using S0 lamb wave mode. While FMC is known for its high-resolution imaging through comprehensive element combinations, it is computationally intensive and time-consuming. VASA, an innovative beamforming method, addresses this limitation by selectively focusing on virtual source locations within near field region, thereby accelerating the imaging process and achieving high main lobe intensity for clearer defect signals. After performing experiments for defect detections at different location, and spatial resolution study (lateral and longitudinal) using both FMC-TFM and VASA-TFM, Results indicate that VASA offers faster imaging with controlled side lobe levels, enhancing defect visibility while significantly reducing computational load. However, a slightly larger Full Width at Half Maximum (FWHM) for VASA suggests a minor trade-off in spatial resolution compared to FMC. Despite this, VASA's efficiency and noise suppression make it promising for real-time and large-scale inspections where speed is critical. Future optimizations in VASA's beamforming parameters could further narrow this resolution gap, combining the advantages of FMC's clarity with VASA's rapid processing.

Keywords: SHM, PAUT, GW, FMC, VASA, TFM, SNR, Ultrasonic Testing.



### Eccentric Virtual Array Source Aperture (EVASA) Ultrasound Imaging Technique Using Phased Array Excitation

**CP 139** 

THE ABSTRACT

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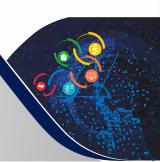
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The traditional phased array ultrasound technique (PAUT) uses active focusing of a set of elements to achieve beam forming and improved imaging capabilities. The recent approach involving FMC/TFM improves this method using synthetic reconstruction approaches. In this research, we introduce a novel hybrid approach that combines active and synthetic focusing at specific angle configurations, utilizing an Eccentric Virtual Array of Source Aperture (EVASA) in the Phased Array Ultrasonic Testing (PAUT) method. Some of the key advantages of this EVASA approach include (a) transmission at a specific angle with focusing at a certain depth (b) Lower time for inspection, (c) improved imaging of defect shapes and sizes, and (d) improved imaging of defects in hard-to-reach regions. The EVASA method employs a custom algorithm where array elements transmit ultrasound waves with pre-calculated delay laws, achieving beamforming focused at eccentric virtual sources located beneath the transducer. These virtual sources will focus at particular depth and angle and send a high amplitude wave into material. Once the desired set of eccentric virtual sources is formed within the material, the synthetic algorithms of FMC/TFM can be used to image the regions of the material. The parameters for these virtual sources, including the number, aperture position, and locations within the material, are based on the propagation angle and focal depth, extending up to the near-field distance. Comparative evaluation with FMC/TFM, using metrics such as SNR, API, defect size, and image processing time, shows significant improvements. EVASA is implemented using standard PAUT probes and instruments, requiring only customization in focal laws and reconstruction algorithms.

**Keywords:** Phased Array Ultrasonic Technique (PAUT), Full Matrix Capture (FMC), Total Focusing Method (TFM), Phased Array Ultrasonic Imaging.





## Scalable Open Software and Hardware Platform for Conventional, Phased-array, Full Matrix Capture and Advanced Ultrasonic Testing.

**CP 140** 

THE ABSTRACT

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Ultrasonic Testing (UT) is increasingly recognized as a reliable inspection method, yet there remains significant potential to enhance its implementation for diverse Non-Destructive Testing (NDT) applications across industries such as aerospace, railways, oil and gas, nuclear power, automotive and steel manufacturing. Full control over ultrasonic instruments and the ability to tailor software solutions are essential for streamlined and effective inspections, from configuring instrument parameters and data acquisition to analysis and reporting. Researchers and academics in NDT also benefit from a flexible, open platform that allows for comprehensive control over testing and measurement processes.

In this paper, we introduce an open, versatile electronic and software platform designed for developing and implementing conventional, phased array, full matrix capture, and imaging techniques. The easily configurable, high-performance hardware, combined with a high-level application programming interface, custom software packages, and a low-level software development kit, provides full access to raw data and allows complete parameterization for acquisition and data streaming. Well-documented low-level SDK and high-level AFM API provide access and control to the instrument. The TFM toolbox library offers a suite of user-friendly functions, unlocking the full capabilities of techniques like delay and sum methods (SAFT, TFM, PWI), migration methods, adaptive methods (TFM, PWI), Penalized method, virtual source aperture etc. Application-oriented fully developed software's like ARIA, FastView, Concerto and Prelude make an easy adaptation of the hardware to any application. The instrument supports high-speed communication, and development is possible in widely used programming languages but not limited to, C++, C#, Python, MATLAB, LabVIEW etc. This allows users and researchers to focus on essential tasks without dedicating valuable time to developing methods for instrument control, configuration management and data acquisition.

Keywords: UT, PAUT, FMC, API, SDK, electronics.



### Baseline-Free SHM of Thin-Walled Structures using Non-Contact Sensing

**CP 141** 

THE ABSTRACT

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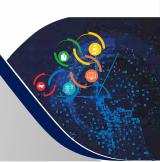
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An efficient and robust structural health monitoring (SHM) technique is essential to prevent catastrophic failures in civil, mechanical, and aerospace structures during their service life. Lamb wave propagation—based techniques for detecting and localizing small flaws in thin-walled structures are among the most robust approaches available. This methodgenerally requires baseline data from the undamaged structure for damage localization. However, a significant concern with baseline-based SHM methods is the change(s) in environmental and operational conditions which can alter the baseline data, potentially leading to false damage alarms. This drives the specific need to develop the base-line free SHM techniques. Further, access to the structures for mounting the sensors and acquiring data is ever-intriguing issue. To address this, in recent years, noncontact measurement techniques have gained significant traction due to their unique advantages and potential applications.

In the present study, a modified damage index is proposed for baseline-free damage localizationof multiple damages in plate-like structuresusingnon-contact measurements of the Lamb wave propagation. The Lamb waves are induced by applying voltage excitation to piezoelectric patch transducers affixed to the surface of the plate. The state-of-the-art facility for non-contact SHM using 3D Scanning Laser Doppler Vibrometer (SLDV), available at CSIR-SERC, Chennai, is used in the present study for acquiring the velocity field. It is found that the velocity field measurement from one narrowband pulse excitation of a given central frequency may not be adequate in identifying the locations of all damages. To overcome this difficulty, a new methodology is proposed for a combined damage index that fuses measurement data of different excitation frequencies. However, obtaining the velocity field data at multiple narrowband frequencies from SLDV required for frequency fusion can be tedious, time consuming and expensive. To address this issue, velocity fields at various narrowband frequencies are virtually derived by utilizing the one-time physical velocity field measurement from a broadband excitation. The effectiveness of the proposed method for damage localization using frequency fusion is experimentally tested on a thin aluminum plate with multiple damages. The proposed technique successfully identifies all damage types considered in the study. The study establishes the effectiveness of the proposed technique for damage localization using the modifiedindex and frequency fusion technique for baseline-free non-contact sensing SHM of thin plate-like structures.

**Keywords:** Lamb wave; Structural health monitoring; Damage localization; Scanning Laser Doppler Vibrometer; Virtual narrowband; Frequency data fusion.





### A Robust Data Driven Framework for The Automated Identification of Weld Damage in Portal Steel Frames Using Impedance-Based Diagnostics

**CP 142** 

THE ABSTRACT

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Structures made from steel play a crucial role in the construction industry, ensuring their durability, strength, and cost-effectiveness. In many steel structures, the members are connected using the welded connection, which can be fabricated quickly and gives a better aesthetic look. On the other hand, welding damage in steel structures is prone to various degradation over time, which could potentially lead to failure of structural integrity. Ensuring accurate diagnosis and classification of damage due to welding in construction steel is crucial for maintaining structural safety and extending the life of infrastructure. Hence, the present study aims to monitor the progressive weld damage in portal steel frames using electromechanical impedance (EMI) techniques via a piezo sensor. At first, three different saw cut damage conditions have been introduced at the single-story portal steel frame with welded connections. The piezocoupled signatures have been recorded for pristine and various weld-damaged conditions. It has been seen that the shifting of peak frequency is well correlated with the progression of weld damages in steel connections. Furthermore, the obtained signals have been converted into scalogram images for different weld damage cases using continuous wavelet transform (CWT) analysis to provide a more localized representation of frequency. The scalogram image datasets obtained through piezo-coupled signatures has been input into the Naive Bayesmachine learning classifier model to localize the damages. In summary, the findings of this study demonstrated promising results in achieving higher accuracy (Approximately 95%), indicating its deployment in practical applications where quick decision-making is critical. This research contributes to the advancement of intelligent health monitoring systems and provides an effective solution for the automated identification of welding quality.

**Keywords:** Electro-Mechanical impedance (EMI), Weld Damage, Machine Learning, Damage Quantification, Scalogram, Steel Connections



### Electromagnetic Simulation Studies for the Detection of Defects in Magnetic Steel Using Third Harmonic Analysis Method

**CP 143** 

THE ABSTRACT

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Detection of inhomogeneities and material loss caused by corrosion or erosion in magnetic steel structural materials is a point of interest for the contemporary research in the field of Non-Destructive Testing (NDT). This work presents an electromagnetic simulationstudies performed in ANYSYS software. The non-linear behavior of the magnetic material through the hysteresis of the magnetisation curve has been used for the study of 3rd harmonic analysis. In the simulation, a 50 Hz sinusoidal voltage is applied to a coil which is placed over a magnetic steel specimen. The sinusoidal excitation current of the coil results in an alternating magnetic field, which induces the magnetic flux in the test part. Based on the test part permeability and physical characteristics, the distortion in the resultant magnetic field is detected on the surface of the specimen at the center of the coil. The received signal is not a clean sinusoidal rather it is distorted wave due to the hysteresis nature of the material. By using the Fourier transform the complete spectral components of the distorted signal is obtained, from which the 3rdharmonic is captured and analyzed. As shown in the fig. 1, the amplitude of the third harmonic (at 150 Hz)is observedas a function of crack depth. The amplitude is reduced with increasing the crack depth. Practically, the harmonic signals are very weak, thus a careful designing of electronic circuitry can significantly improve theharmonic signal by separating the noise. Further in support to the simulations, experimental studies will be carried out to detect the defects in the test material using this method.

Keywords: Magnetic Steel, Sinusoidal Excitation, 3rd harmonic, Fourier Trasform.

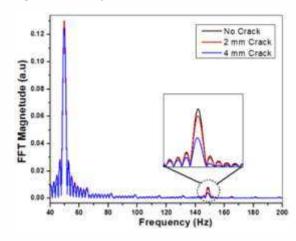


Figure.1. FFT of the received magnetic field, 3rd harmonic is represented in magnified view.





# Experimental Investigations on the Scale Model of Prestressed Concrete Bridge Girders to Study the Effect of Prestressing Force on the Time and Frequency Domain Responses

**CP 144** 

THE ABSTRACT

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Evaluation of existing prestress force is essential in structural systems, as the dynamic properties of a Prestressed Concrete Bridge (PSCB) depends on various factors such as tension in the cable, mass and stiffness. Understanding the prestress force influence through the signal analysis techniques for varying prestress force levels is limited in real world applicability. Therefore, experimental investigation is conducted on a T-girder which focusses on the signal processing techniques. A free vibration test is conducted using impact hammer excitation at different locations for various prestress force levelsto analyse the quantitative behaviour in the time domain data such as Root mean square (RMS), skewness, and kurtosis and the frequency domain analysisusing Fast Fourier Transform (FFT) is used to analyse the natural frequencies, frequency shift, frequency square, frequency ratio offset(FRO). Additionally, time-frequency domain analyses such as Short-Time Fourier Transform (STFT), wavelet transform, Hilbert transform (HT) are also analysed to capture the dynamic response characteristics for various prestress force levels.

The observations of the time domain analysis for kurtosis proved to be more effective than other statistical methods, with kurtosis values showing a significant increase for maximum prestress force with the distribution pattern peakierfor the higher prestress force levels. Similarly, in frequency domain analysis the frequency shift is maximum for higher prestress forceswithminimal frequency ratio offset changes in lower mode shapes. Time-frequency analysis using wavelet transform provides a clear representation of transient changes and frequency shifts for the maximum prestress force compared to STFT and HT. Thestudy establishes a framework for using the multi domain approach to quantify the prestress induced changes more accurately in prestressed concrete structures.

**Keywords:** dynamic analysis, signal processing techniques, prestress force.



### Applications of Multi-Channel Ultrasound System for Assessing Large Concrete Structures

**CP 145** 

THE ABSTRACT

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Non-destructive testing (NDT) plays a vital role in assessing large concrete structures, where detecting internal defects is challenging due to size, material heterogeneity, and complex geometries. In this study, the application of a multi-channel, large-aperture ultrasound system is demonstrated, enhancing the traditional ultrasonic pulse-echo method for evaluating such structures.

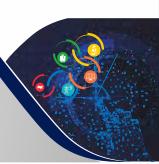
The large aperture of the ultrasound system allows for broader coverage and increased sensitivity to critical internal features such as cracks, voids, and embedded components within the concrete. By capturing data from multiple channels simultaneously, the system significantly enhances both resolution and depth penetration, providing a clearer and more comprehensive image of the structure's internal integrity. This enhanced approach applies a weighted sum of the Kirchhoff migration technique for post-processing the data, yielding better visualization and detailed interpretation of the structure's internal condition. This methodology proves especially valuable for thick, complex materials where traditional techniques often face limitations.

Additionally, the time-of-flight (TOF) tomography method complements the pulse-echo technique by providing quantitative analysis of internal structures. Utilizing precise time-picking techniques, TOF tomography enables the accurate mapping of anomalies within the material, offering valuable insights into the condition of concrete structures with varying geometries and compositions.

Together, these two methods-pulse-echo imaging with the large-aperture multichannel system and TOF tomography-offer complementary options for assessing large concrete structures. The pulse-echo technique focuses on delivering detailed images of structural defects, while TOF tomography provides quantitative data on internal features. This combined approach offers a comprehensive and reliable methodology for evaluating and ensuring the longevity of large-scale infrastructures.

Keywords: NDT-CE, Ultrasonic Testing, Large Aperture Ultrasound System (LAUS), Concrete Structure





### Investigation of Sensitivity and Real-Time Processing of Distributed Acoustic Sensing Data

**CP 146** 

THE ABSTRACT

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Distributed Acoustic Sensing (DAS) is an unique modality that uses a fiber optic cable as an effective replacement for an array of microphones or hydrophones, thereby finding applications in structural health monitoring as well as intrusion monitoring. One of the key performance parameters is the sensitivity of the DAS instrument, which depends primarily on the phase noise of the system. In this paper, the sensitivity of DAS has been tested experimentally using a 20 km optical fiber connected to a piezoelectric transducer that can stretch and compress the fiber inducing phase change to the backscattered light. The piezo drum has 40 m of fiber wound around it and is excited with a sinusoidal input for varying voltages. We find that the developed DAS instrument is capable of detecting phase change of up to 22 milliradians corresponding to 1 mVpp signal with a SNR of 20 dB, limited only by the function generator output voltage.

Since DAS is a spatio-temporal sensor, it generates a large amount of data - around 9.6 GB every minute. Users relying on DAS for surveillance or critical application require the data to be processed on a real-time basis and log only necessary processed data. The usual processing algorithm which includes fundamental processing and fading mitigation techniques would take around 30 seconds to process in a CPU. We have successfully mapped the algorithm to Graphical Processing Unit (GPU) coded in CUDA C++ for parallel multi-thread processing and perform the same under 75 ms. A GUI has also been developed to display the process result as a waterfall plot, which will be demonstrated during our presentation.

Acknowledgement: The authors would like to thank NRB for the financial support to conduct this research.

Keywords: Distributed Acoustic Sensor, OTDR, Optical Fiber Sensor.



### Elastic Reverse Time Migration for Improved Ultrasonic Imaging of Concrete Constructions

**CP 147** 

THE ABSTRACT

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The ageing concrete infrastructure worldwide requires a thorough inspection and assessment. The traditional visual and tap testing methods required by many national and international standard have been meanwhile amended by more sophisticated tools like ultrasonic or radar echo technologies. While they can provide a much more detailed image of the interiors of concrete constructions, there are still several unsolved testing tasks on the wish list, such as the reliable sizing of internal objects, e.g. tendon ducts.

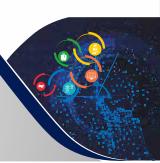
Reverse Time Migration (RTM) is an imaging technique which is in use in the oil and gas industry for the exploration of new resources with seismic waves as a standard tool. Since about ten years there has been R&D effort to use RTM for imaging of ultrasonic echo data. As it uses the entire wavefield, RTM has some advantages compared to traditional SAFT, e.g. the ability to image vertical structures or the backside of objects. However, this comes with the cost of having to perform full wavefield simulations. We have adopted, improved, and used open source 2D full elastic codes (P/SV waves and SH waves) from geophysics to evaluate the capabilities and limitations of RTM for the imaging of certain features in concrete constructions. We can show the advantages of SH-wave RTM in comparison to SAFT, acoustic RTM and P/SV-based RTM.

The findings are demonstrated based on simulated and real data, using a reference test specimen available at BAM. Position and diameter of tendon ducts have been determined with a sub-cm accuracy.

**Keywords:** Concrete, ultrasound, imaging, reverse time migration, RTM.

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# CFD Simulation and Analysis of Natural Gas Leakage in Buried Pipelines: Development of Temperature-Based Leak Detection and Monitoring using Distributed Temperature Sensing (DTS) Technology

**CP 149** 

THE ABSTRACT

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Natural gas pipeline leaks, particularly in buried infrastructure, present significant safety and environmental challenges. This study focuses on developing an advanced leakage identification system using Distributed Temperature Sensing (DTS) technology, capable of detecting temperature variations along pipelines. A comprehensive Computational Fluid Dynamics (CFD) analysis was conducted to simulate natural gas leakages in buried pipelines with diameters ranging from 1 mm to 25 mm. The study explores the effects of varying inlet flow, gas pressure, temperature, leak location, and soil properties on temperature distributions around the leak site. The results from the simulations show distinct temperature profiles around the leakage areas, which are influenced by both the leak size and the surrounding soil conditions. For instance, larger leaks exhibit more significant temperature drops around the leakage area, providing a clearer signal for DTS detection. Conversely, smaller leaks require more sensitive analysis techniques due to the subtle temperature gradients they produce. This study emphasizes the importance of considering soil type and properties in the modeling process, as different soils exhibit varying thermal conductivities, significantly impacting the dissipation of heat from the leaking gas. By refining the CFD models and correlating the temperature profiles with DTS data, it is aimed to develop an accurate, realtime monitoring system that can detect leaks even in their early stages, potentially preventing catastrophic failures. The findings contribute to the ongoing development of leakage detection systems in the oil and gas industry, providing a crucial step toward ensuring pipeline integrity and enhancing safety. Future work will focus on refining the correlation between simulated data and real-time DTS readings, aiming for the deployment of an operational monitoring system for natural gas distribution pipelines.

**Keywords:** CFD, Natural Gas Leakage, Distributed Temperature Sensing, Leak Detection, Pipeline Integrity, Thermal Analysis



### Evaluation on Autonomic Self-healing of Micro- Crack Using Non-Destructive Monitoring Technique.

**CP 150** 

THE ABSTRACT

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Crack formation and propagation in concrete structures remain critical challenges in modern construction. These issues can significantly compromise structural integrity, durability, and service life. Early detection and understanding of crack development are crucial to mitigating potential structural failures. Despite advancements in construction materials and design, effectively controlling and preventing crack formation remains a challenge, especially in aging infrastructure. This paper monitors healing in a cracked concrete specimen using ultrasonic waves. The healing agent, consisting of silica and calcium-based chemicals, reacts to produce crystalline hydrates. Then, it forms a calcium silicate hydrate gel-like crystalline substance that gradually fills the cracks as healing progresses. We cast several concrete specimens with varying water-cement ratios and introduced cracks through mechanical loading. We subjected the cracked specimens to two treatments: manually injecting the healing substrate into the cracks and soaking the precracked specimens in lime water with a three-day wet-dry cycle for up to 28 days. Besides, we monitored the specimen's signal variations using UPV pulse transmission at regular intervals throughout those 28 days. Further, in this study, we examined the differences in compressive strength of the pre-cracked specimens before and after healing, healing percentages, and pulse rate variations based on crack patterns. The observation signifies that as healing progresses in the cracked concrete, the strength of the ultrasonic signal increases. Additionally, we carry out a water permeability test to ascertain the healing percentage. Finally, the results demonstrate the efficacy of the silicate and calcium-based chemical healing agents in repairing existing cracks. Also, the UPV pulse transmission outputs provide strong evidence of the healing process.

**Keywords:** Concrete, Micro-cracks, Healing agent, Monitoring technique.





#### Performance Evaluation of Array Based Digital Detector Used in Radiography Testing of End Plug Welds of Fast Breeder Reactor Pins

**CP 151** 

THE ABSTRACT

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Digital Detector Array (DDA) based Radiography Testing (RT) techniques are fast, efficient, and being increasingly adopted in industrial applications. Their high quantum efficiency supports the lower exposure times in large-scale volumes of RT. Fast Breeder Reactor (FBR) pin end plug welds are also examined and qualified using DDA based digital RT techniques. It is very important to meet the image quality to get the required sensitivity in RT. Various parameters of a digital radiography system influence image quality and many of which are directly linked to the performance of the DDA. In addition to the regular calibrations such as offset corrections, gain calibration etc., ensuring the long-term stability DDA is also crucial for maintaining image quality in digital RT. Evaluation and tracking of the fundamental parameters also helps to determine base line performance in checking the long term stability & degradation of DDAs.

This paper presents the procedure and outcomes of the long-term stability checks of a Gadolinium Oxy-Sulfide (GOS) scintillator-based DDA used in RT of Prototype Fast Breeder Reactor (PFBR) pin welds. The study has been carried out using a customized duplex plate phantom incorporating a hole-type Image Quality Indicator (IQI) and a duplex wire gauge. The phantom was designed based on the RT thicknesses encountered in actual production scenarios of variousPFBR pins. A 320 kV milli focus X-Ray source was used for the exposure of DDA with geometrical and exposure parameters as recommended in ASTM E 2737. DDA's performance was assessed based on several image quality parameters, including Signal-to-Noise Ratio (SNR), Spatial Resolution (SR), Signal Level (SL), Contrast Sensitivity (CS), Image Lag (IL), Offset Level (OL), Bad Pixel distribution etc. A good contrast sensitivity of 0.97% and 1.46% in thin and thick portion of phantom has been achieved. The obtained low value of image lag indicates sound condition of DDA electronics.

Keywords: Digital Detector Array (DDA), Digital RT, SNR, contrast sensitivity, performance



### Role of NDE in Qualification of Biocompatible Implants

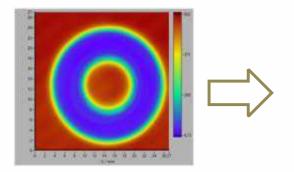
**CP 152** 

THE ABSTRACT

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Developing and evaluating biocompatible implants for medical use is a critical research area, as these devices significantly improve patient's quality of life. Ensuring the safety and effectiveness of implantable devices is paramount, and non-destructive evaluation techniques have become a valuable tool in the qualification process. First, this study aims to conduct a Failure Mode and Effect Analysis of cardiovascular implants to identify potential failure modes, their effects, and causes and develop preventive actions to mitigate these risks during the design and development stage. The analysis will involve creating a boundary diagram to map the various subsystems and components of the system and their interfaces, a fishbone diagram to systematically identify potential root causes, a parameter diagram to visually define the system's functioning, and an FMEA table to document the potential failure modes, their causes, effects, and proposed mitigation strategies. The goal is to address the serious and potentially life-threatening consequences that can arise from the failure of such devices to function effectively. Second, characterizing the materials of biocompatible implants must consider their intended functionality and account for the impacts of manufacturing, handling, sterilization, and storage. The assessment plan comprises two key elements: physicochemical and biological evaluation. The physicochemical component examines the fundamental physical, chemical, mechanical, structural, and surface attributes of the materials. The biological characterization encompasses assessments of cytotoxicity, toxicology, blood compatibility, tissue response to implantation, carcinogenic potential, and mutagenic effects. This paper examines the various non-destructive techniques employed to analyze the materials and components utilized in biocompatible implants, particularly in the context of cardiovascular devices.

Keywords: NDE, Quality assurance, THz



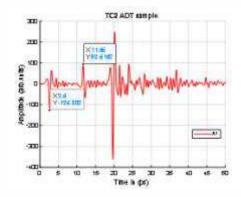


Figure 1.THz raster scan and thickness profiling





#### **Discovering Flexible detectors**

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**CP 153** 

THE ABSTRACT

The introduction of the bendable digital detector technology represents a significant evolution for field radiography inspections. Designed for the application on round objects down to 150mm (6") in diameter, the DXR Flex closely encircles pipe welds, previously only possible with X-ray film or CR phosphor imaging plates. It thereby covers a larger part of the weld area that needs to be inspected than rigid flat panel detectors, allowing the overall inspection to be concluded with up to 65%\* fewer exposures. This in turn drastically reduces set up and inspection time, and ultimately overall asset downtime.

- **1.1 Resolution :** What is the difference between scan resolution and achieved SRb (basic spatial resolution)? What are the influencing factors for SRb and how can it be improved? We will give a deeper explanation on both with some examples.
- **1.2 SNR Signal to Noise ratio :** Defining the difference between SNR and SNRn, is one of the most important factors to define final outcome of a CR system. We will explain in detail the influencing factors of both SNR and SNRn, as they are mentioned in the available international Standards, covering digital inspection technology.
- **1.3 Scintillator Type:** Difference bewtween CsI (Cesium Iodide) vs. Gadox (Gadolinium oxysulfide), selection of various available pixels with respect to application.
- **1.4 Fill-factor:** Very important factor to measure the efficiency of the DDA, why it is a important parameter for selecting high resolution DDA.
- **1.5 Backscattering:** How backscattering negatively influences image quality, how it can be prevented.
- **1.6 Standards:** Defining various local and international standards (EN, ISO, ASTM, API...) in compliance with SNR, SRb, energy, distance & shielding parameters.
- **1.7 Detector capability:** Ingress protections, communication methods, shielding, operating time & battery capabilities.
- **1.8 Software package:** Even more important than the available CR system, would be the capabilities of the software. Is it merely a Medical software with a light NDT layer, or a real dedicated NDT package? Which features are included that will help and guide the operator? Is there availability of unique and patented image enhancement software like BHGE's Flash!, revealing all possible defects on the digital images? What is DICONDE and why would it be important for my inspection? Can I drive other technology with my purchased software? We will give an answer to these relevant questions.
- **1.9 Price:** Probably the most underestimated parameter when it becomes to comparing and choosing a DR system! Where can I found out these DR system values, and how can they influence my total project time? Again, we will give detailed information on this important aspect during the presentation.
- 2. **CONCLUSIONS:** Finally, being informed on the above influencing parameters, any future user of DR technology, can decide which system to acquire. But would there be any extra support from the various system suppliers before the decision is made?



### A unique approach to identify surface and sub-surface flaws by IR imaging

**CP 154** 

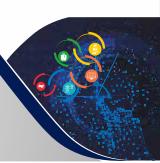
THE ABSTRACT

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Active thermography using pulsed heating is a fast and reliable method for defection of flaws in composite and metallic materials. The aim of the study is to identify surface and subsurface flaws in stainless steels in a non-contact manner. A stainless steel specimen (100 mm X 100 mm X 12 mm) with flat bottom holes (FBHS) of varied diameters at different depths wasfabricated. The same specimen was also engraved with artificial scratches onto the surface to simulate surface flaws. The specimen was black painted to avoid emissivity variations. A FLIR camera X6540sc wasused to acquire the thermal data sequences subsequent to pulsed heating. The camera has an indium antimonide (InSb) semiconductor detector array with Stirling cooling system. The spectral response range of the focal plane array is 1.5-5.1  $\mu$ m. The temperature resolution of the camera is 25 mK.The specimen was kept at a distance of 60 cm from the camera to cover the entire sample within 320x256 pixels of the detector. These parameters resulted in a resolution of  $\approx$ 0.37  $\times$ 0.37mm2 in the specimen frame.The temperature decay was recorded for 5 seconds, subsequent to pulsed heating amounting to 2000 frames of data, including 10 pre-frames. The recorded data sequences were analysed by a proposed equivalent circuit approach, where the time-temperature data were fitted with non-linear least square approach. The optimisation of fitting parameters was carried out in Origin®. The decay constants derived from the proposed approach could clearly detect and distinguish surface and subsurface flaws.

Keywords: Infrared thermography, equivalent circuit model, temperature decay, time constant





### **Detection of Surface Opening Flaws Using Eddy Current Array Technique**

CP 155

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THE ABSTRACT

Conventional Eddy current technique is commonly used for inspection of conductive material components in petrochemical and power industries. This paper explores the application of Eddy Current Array (ECA) techniques for detecting surface flaws in conductive materials, highlighting the limitations of conventional Eddy Current Testing (ECT). Traditional Eddy Current Testing employs single absolute or differential coils, leading to lengthy inspection times due to limited scanning areas and challenges in detecting defects oriented in specific directions. In contrast, Eddy Current Array enhances inspection efficiency by providing broader coverage and faster scanning capabilities, which significantly reduces operator dependency while improving flaw detection accuracy. To validate the effectiveness of ECA, the study involved the preparation of test samples with artificially induced notches. These samples were systematically inspected using the Eddy Current Array technique. The results revealed that ECA successfully identified all notches, demonstrating its reliability and superiority over conventional methods. This capability makes ECA particularly advantageous for industries such as petrochemical and power, where timely and accurate flaw detection is critical. The paper details the methodology used in the inspections, including the setup, scanning techniques, and analysis of results. It provides insights into how ECA can be effectively implemented in real-world applications, addressing common challenges faced in conventional testing methods. The findings underscore the potential of ECA to revolutionize surface flaw detection, making it a robust solution that enhances operational efficiency and safety in critical industrial sectors. Overall, the study presents compelling evidence for the adoption of ECA, emphasizing its role in advancing nondestructive testing methodologies.

Keywords: Eddy current array, surface flaw, conducting material



## Studies showing the significance of dual-modesecond-harmonics (DMSH) generated on plate and cylindrical structures

**CP 156** 

THE ABSTRACT

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Detecting damage in critical structural components early iscrucial to prevent unexpected structural failures that could lead to disasters. Nonlinear ultrasonic (NLU)quided wave (GW) techniques are evolving into an effective method for measuring the early stages of structural degradationbyanalysing higher harmonics. Recent studies have unveiled the presence of two dominant second harmonic guided wave modes termed as dual-mode second-harmonic (DMSH)when excited with non-dispersive guided wave modes on plates or cylinders. For a weakly nonlinear plate, the presence of simultaneously propagating DMSH fundamental symmetric (s0) and orthogonal-shear horizontal (sh01) modes was observed. Similarly, for a weakly nonlinear cylinder, the presence of simultaneously propagating DMSH fundamental longitudinal (I(0,1)) and orthogonal-torsional (t(0,1)□) modes were observed along with double flexural modes (F(1,1) and F(1,2)) at primary frequency. The DMSH modes possess different group velocities and thus each wave packet can be identified in time domain analysis as separate signals. The present work demonstrates the significance of the DMSH on localized material degradation. The localized material degradation is modelledin FEA simulationsby varying the third-order elastic constants, realizing the material degradation. A few case studies by varying the localized material degradation by location and intensity are performed on the plate and cylinder media. The displacement profiles were monitored along the propagation direction to analyse the influence of enhanced material nonlinearity on the propagated wave. Theoretical dispersion curve analysis and frequency-time-based signal processing techniques are employed for the identification of the guided wave modes. It was found that the newly discovered sh0 and t(0,1) modes were more sensitive while other GW modes present were seemingly unaffected. This research could significantly impact early-stage defect detection in structural health monitoring and nondestructive evaluation of critical structures.





### Infrared Thermal Imaging of Composites by Cooling

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**CP 157** 

THE ABSTRACT

Composites are replacing metals in many applications today due to their superior properties of Strength, Weight, Durability, Corrosion Resistance, and flexibility. However, due to their composition, conventional NDT cannot be used to test the integrity of these materials.

Infrared Thermal Imaging is able to give us several credible results for testing the composites. Majority of the industry uses active thermography to get better sensitivity and instant results. Inactive thermography the method uses heat flow to inspect composite materials and detect flaws The heating is normally done through a heat source, like a lamp or laser And it is used to excite the material and generate heat flow An infrared camera monitors the Heat flow and captures images of the surface temperature changes These images are used to interpret and determine the materials condition and properties Generally, this method is used to detect delaminations, voids inclusions or disbands in the honeycomb structures along with water ingress detection .

However, most of the active thermography is done by heating the material and creating a temperature difference This heating is done either through heating blankets or with the usage of localized sprayed guns because of the composition of composites The Heat dissipation happens very fast irrespective of whether we are testing frp or metal matrix composites. Unfortunately, the material gets extremely hot and becomes difficult to handle because of the excessive heat dissipated in the material The author did some experiments typically on gfrp and cfrp And aircraft components including some honeycomb structures instead of heating the material We did reverse thermography by creating a temperature difference by cooling the material The results were very similar. There was an added advantage of material not getting heated up because of which it was easy to handle Also material properties were not damaged since the material was not subjected to excessive temperatures.

The paper details the experimental results along with the reasons of why temperature differential of cooled temperatures must be used wherever it is practically possible.

Keywords: Thermography, Cooling, Active thermography, Honeycomb, CFRP, GFRP



## Inspection of Barely Visible Impact Damage in Carbon Fiber Reinforced Composite plate using an Acoustic Camera

**CP 158** 

THE ABSTRACT

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At present, various types of composites are widely employed in structural applications. Owing to their elevated specific strength, durability against corrosion and wear, and light weight, composite materials are favored. The presence and vulnerability to internal defects or flawed characteristics pose a challenge in the application of composite materials. It is essential to use or develop an effective non-destructive testing (NDT) technique that can be employed to detect minor damages like BVID/IVID. This work mainly focuses on the development of an acoustic camera with an array of microphones and a data processing unit with a Raspberry Pi. Acoustic cameras are extensively utilized as a device for noise source analysis. To test the overall functionality of an acoustic camera, an impacted composite sample with BVID is tested. The composite sample of dimension (100×100×3mm) is fabricated using Vacuum assisted resin transfer molding process. Later, different energies (7.14 and 3.65 J) impacts are done using an in-house custom developed automatic, portable low velocity impactor, which generates the defects called barely visible impact damage (BVID). The data processing unit Raspberry Pi accepts PCM (I2S/I2C) data. To use a PDM microphone directly with a Raspberry Pi, it is required to change the data format from PDM to PCM, which is done using the ADAU7112 chip. At last, after concatenating the acoustic data captured from microphones, an acoustic image is formed that is overlaid on a real image, captured initially using an onboard camera set on the microphone array PCB. In this manner, a comprehensive setup for acoustic testing utilizing an acoustic camera is established and executed.

**Keywords:** Non-Destructive Testing (NDT), Barely Visible Impact Damage (BVID), Invisible Impact Damage (IVID), Vacuum Assisted Resin Transfer Molding (VARTM), Pulse Density Modulation (PDM), Pulse Code Modulation (PCM).





### Embedded Sensors for Quality Control and Structural Integrity Monitoring of Large-scale 3DCP Structures

**CP 159** 

THE ABSTRACT

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In extrusion-based 3D concrete printing (3DCP), addressing challenges related to safety, reliability, and quality control is crucial for widespread adoption. Yet current limitations in monitoring material properties during and after printing hinder the development of effective 3DCP guidelines. Therefore, the development of an inline sensing system capable of real-time monitoring and adjustment of process parameters is necessary to overcome these challenges. Building upon an existing inline sensing system developed by BAM, which currently monitors material properties during printing, this study extends its capabilities to post-extrusion monitoring using embedded piezoelectric (PZT) sensors. These PZT sensors provide localized measurements of material changes through electrical impedance (EI) measurements without disrupting the printing process. By embedding these sensors in large-scale 3D printed structures, continuous monitoring is achieved from layer deposition through entire hydration. The changes in El response of the sensor are related to key material properties, such as green strength, thixotropic buildup, and hydration, offering valuable insights into the structural property evolution of the printed elements. To achieve this, initially, PZT sensors were developed with multiple layers of protective coatings. Two different 3D printed mixtures, each with varying yield strengths, were produced, and PZT sensors were strategically placed between printed layers to maintain their integrity. El measurements were collected continuously from printing through three days of hydration. Analysis of amplitude and frequency changes in the El response spectrum provided insights into material behavior post-printing. Furthermore, correlations between changes in conductance measurements from the PZT sensors and real-time torque data from the pumping system revealed critical information about differences in the green strength of the mixes. The study highlights how continuous monitoring of frequency and conductance can track structural buildup and property development of the material. Rapid changes in conductance measurements, immediately postprinting indicate swift structural buildup, while key hydration phases are reflected in frequency measurements. By developing methodologies to extract fresh material properties from El measurements, this research enables real-time adjustments during 3D printing to prevent failures, enhance performance, and ensure long-term structural monitoring of printed elements.

**Keywords:** Embedded Sensors, 3D Concrete Printing, Quality Control, Inline Sensing, Structural Integrity, Sustainability in Construction.



#### Towards Optimal Safety Factors in Hydrogen Vessels through SHM Implementation

**CP 160** 

THE ABSTRACT

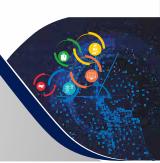
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This study focuses on the cylindrical section of high-pressure hydrogen composite vessels for fuel cell vehicles (FCVs), which are fabricated by overlaying carbon fiber-reinforced plastic (CFRP) on a resin liner. Traditionally, these vessels have followed a safe-life design approach, which requires an initial burst pressure set at 200% of the nominal working pressure (NWP) to ensure vessel safety over its entire operational lifespan. However, by implementing Structural Health Monitoring (SHM), specifically Acoustic Emission (AE) testing, this research aims to adopt a more efficient damage-tolerant design approach to achieve an optimal safety factor by reducing the initial burst pressure requirement to 180% NWP. This reduction in safety factor not only ensures vessel integrity but also allows for potential cost savings and lighter vessel construction, which are particularly beneficial for FCV applications. In this framework, AE testing is applied exclusively to detect fiber bundle ruptures, while the occurrence of other damage modes, such as resin cracking and delamination, is tolerated within the design to prevent vessel burst and extend service life.

To realize a damage-tolerant pressure vessel with the thinnest possible wall thickness, a stacking sequence optimization method was developed. The optimization was conducted under conditions that allow for non-fiber bundle rupture damage modes at 180% NWP and ensure that even if fiber bundles in two CFRP layers completely rupture, the vessel would not burst at 125% NWP. As a result, this approach demonstrated not only the potential to achieve an optimal safety factor but also a significant reduction in vessel thickness compared to designs based on traditional safe-life design principles.

**Keywords:** High-Pressure Hydrogen Vessels, Fuel Cell Vehicles, Structural Health Monitoring, Acoustic Emission, Damage-Tolerant Design, Stacking-Sequence Optimization





### Girth weld inspection with DLA probes and real-time Adaptive TFM and Plane Wave Imaging

**CP 161** 

THE ABSTRACT

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Phased array ultrasonic testing is mainly used for these inspections which have to be carried out on site with difficult access to the piping. This task is particularly challenging due to the types of austenitic stainless steels that are generally used in piping which creates structural noise in the ultrasonic signals.

In addition, the deformation of the surface profile in the vicinity of pipe bends leads to image reconstruction problems and the appearance of non-inspectable areas. In order to efficiently address these issues, we implemented a real-time Adaptive Plane Wave Imaging (APWI) technique using a Dual Linear Array (DLA). The Plane Wave Imaging technique provides great performances for weld inspections. It enables inspection of a large area with fine resolution, and careful selection of the range of angles to be transmitted within the medium. Unlike the standard Total Focusing Method (TFM), each plane wave excitation is generated by all transducers.

Therefore, it delivers a large amount of energy inside the weld which is strongly attenuative due to the scattering. A large part of plant's piping system is straight and can be inspected efficiently with standard PWI.

Nevertheless, standard technique cannot adapt to the curvature of elbow pipes that present various kind of geometries and material distortions. For these geometries, we have implemented an innovative adaptive algorithm that can be used in a DLA configuration and in real-time.

A first shot of plane waves is used in pulse-echo in order to detect the surface profile and monitor the coupling. The second plane wave shot is used in pitch-catch with higher angles in order to reach the region of interest and is then reprocessed by taking the surface into account.

This adaptive algorithm is compatible with the use of phase coherence techniques which offer enhanced performance for diffraction echoes detection.

Keywords: Plane Wave Imaging, real-time adaptive imaging, Dual Linear Array, girth weldinspection.



## Non-Destructive Evaluation Approach for Linear Bellow Systems in Indian Launch Vehicle Heat Shield Separation Mechanisms

**CP 162** 

THE ABSTRACT

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The Linear Bellow System (LBS) is an explosive-based separation mechanism utilized for deploying the heat shield fairings on all launch vehicles developed by the Indian Space Research Organisation (ISRO). The system incorporates explosive cords encased within a rubber bellow that is fitted inside a metallic piston-cylinder configuration, connected through rivets. Ensuring the reliable operation of the LBS is critical for the timely separation of heat shield fairings at predetermined altitudes, facilitating the successful deployment of payloads into their intended orbits.

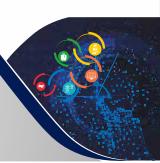
ISRO is currently working on new developments of the bellow design to reduce turnaround time and to align with the demands of the next-generation launch vehicles. During recent functional testing of developmental LBS units, a performance anomaly was observed in one unit, prompting an investigation into potential failure modes. As part of this assessment, digital radiography testing was conducted on the anomalous unit alongside a properly functioned unit. Further insights into the conditions of the failed LBS was obtained through Computed Tomography (CT) testing.

Traditionally, ultrasonic testing (UT) is employed to verify the integrity of rivets in the LBS assembly. However, the recent anomaly in the developmental unit highlighted the importance to evaluate the condition of the bellow as well using an appropriate non-destructive testing (NDT) technique. Radiographic testing (RT) was selected for this purpose; however, the low-density nature of the bellow material presented challenges in assessing its structural integrity. Following the failure analysis, the root cause of the anomaly was identified, and reference samples with varied bellow assembly conditions were prepared for further validation.

This paper presents the non-destructive evaluation (NDE) methodology applied to assess rivet integrity, details the failure analysis of the anomalous unit, and discusses the successful implementation of techniques to evaluate diverse bellow conditions in reference LBS units. Additionally, the study explores the feasibility of applying the same NDE approach to inspect LBS assemblies within the heat shield fairing system.

Keywords: NDE, Linear Bellow System, Heat shield Separation, Failure Analysis, Radiography Testing.





### NDE 4.0. Realizing zero-defect mass production of spotwelds by integrating AI into the advanced ultrasonic quality monitoring process.

**CP 164** 

THE ABSTRACT

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Rouslan Rakhoutine BSc., MEng., MBA, Tessonics Group

In the presentation, we will introduce recent results in developing advanced NDE technology which allows to realize zero-defect mass production of bonded joints by integrating AI into the real-time ultrasonic quality monitoring process. It will be demonstrated a few successful results, including implementation of the real-time automated spot weld quality evaluation using deep learning-based the ultrasonic B-scan analysis. Using a proprietary deep learning algorithmallows us to classify welds as good, acceptable, or bad in real-time during the welding process. As a result, this solution enables the NDE specialists to modify currently used automotive adaptive systems, which control the welding process and produce high quality welds that match the production-level requirements.

Also, we will cover the topic of the spot weld control using multichannel transducers for postproduction QC process. Using multichannel transducers allows us to get graphical image of the spot weld and to see possible defects to achieve faster and more accurate results compare to traditional methods.

Additionally, thereis another important aspect of this problem, and this is crucial for manufacturing cycle timesthatsuchrecognition is realized in real time. The developed high speed proprietary algorithms allow the system to make real-time decisions and send anon-line request to the welder to modify the welding parameters to make sure that at the end of each spot-welding cycle the quality of each weld corresponds to a good weld, which is a great example of advance NDE 4.0 solution.

We are confident that when the various aspects of this problem will be resolved and the persistence of the results demonstrated, the developed approach to zero-defect quality will revolutionize the modern manufacturing process, inparticular, the automotive assembly plants globally. This technology has the potential to bring big savings in production, reduce labor costs and eliminate unnecessary destructive tests, which are still part of today's quality inspection process. The main goal of our research is to achieve the zero-defect mass-production which was demonstrated by our team at the pilot plant.



### X-ray Fluorescence Method-A Rapid and Reliable Alternate for Thickness Measurements on Multi-layer metallic coatings

**CP 165** 

THE ABSTRACT

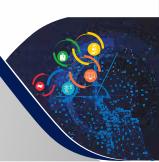
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Single and multi-layer metallic coatings are applied on various metallic hardware and semi-cryo propulsion engines of satellite launch vehicles to meet harsh environments and functional requirements like resistance to corrosion, abrasion, chemical reaction, and improved solderability and thermal insulation properties. Tactile NDT methods are generally used in coating thickness assessment, in addition to the metrology and destructive micro sectioning and coulometric methods. The accuracy and reliability of the coating thickness measurements by tactile NDE gauges and probes depend upon many factors, including the conductivity and magnetic permeability of both the coating and the substrate. The geometrical features of the sample, like curvature, proximity of edge and surface roughness, also influence the measurement accuracy a lot.

In this study, a Multi-layer coated steel sample simulating a functionally critical semi-cryo engine component is subjected to various coating thickness measurement methods, including tactile magnetic induction gauging, CMM measurements, and SEM analysis. In addition, the EDXRF method in standard less fundamental parameter mode and empirical mode with calibration standards are also attempted on the sample. This study compares individual layers and whole thickness at identical locations on the sample and analyses the causes of variations in each method. The EDXRF has proved to be the most rapid and reliable method in assessing the top layer coating. It also discusses the relative advantages of EDXRF methods. It brings out a novel simulation of the empirical mode to arrive at the correction factor to be applied to the measurement of the intermediate and undercoat of the sample. Keywords:

Multi-layer metallic coating, Semi-cryogenic engine, Empirical mode, Tactile Magnetic induction gauging, fundamental parameter mode, Undercoat, Intermediate coat.





# Evaluation of Data Processing Techniques for Enhanced Defect Detection in Active Thermography of composite material

**CP 166** 

THE ABSTRACT

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In the field of Thermal Non-Destructive Testing and Evaluation (TNDT&E), active thermography has gained increasing attention due to its ability to assess structural integrity and strength without impacting the material's future utility. This study focuses on the application of active thermography for evaluating Carbon Fiber Reinforced Polymer (CFRP) materials, simulating defects in the form of 12 flat bottom holes with varying depths. The investigation employs a Pulse Compression Favourable Frequency Modulated Thermal Wave Imaging (FMTWI) technique to enhance defect detection capabilities. To improve signal analysis, we compare the Pulse Compressed signal with several processing approaches, including polynomial curve fitting for offset removal and Principal Component Analysis (PCA), an unsupervised learning technique for effective data reduction and signal standardization. We also explore median centering as an alternative offset removal method, aiming to standardize the data and optimize defect detectability. The effectiveness of these methods is assessed by analyzing the Probability of Detection (PoD) curve, which relates the detectability of defects to the aspect ratio (diameter to depth) and Signal to Noise Ratio (SNR) of the features. To further quantify defect detectability, Peak to Sidelobe Ratio (PSLR) is employed for SNR calculation. Our results demonstrate that PCA enhances defect detectability in CFRP samples when combined with pulse compression, showing a superior PoD in comparison to traditional offset removal methods. This study underlines the potential of advanced signal processing methods, particularly PCA, in improving the sensitivity and accuracy of TNDT&E for CFRP materials, offering valuable insights for industrial applications requiring precise defect identification and characterization.

**Keywords:** frequency modulated thermal wave imaging, principal component analysis, pulse compression, probability of detection.



### To design a Deep-Learning Architecture for fast and reliable defect detection in solids

**CP 167** 

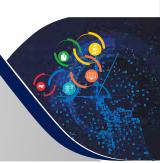
THE ABSTRACT

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Infrared imaging has become an indispensable tool in predictive maintenance and monitoring of different equipment for early fault detection. The integration of Machine learning models in the infrared imaging makes the system automated and make it highly efficient and optimized. This innovative application harnesses the power of artificial intelligence to analyze thermal images and identify faults, or defects in various materials and structures. By training neural networks on a diverse dataset of thermographic images, the system can learn to recognize patterns associated with defects, making it highly adaptable to the different inspection scenarios. Deep learning architectureparticularly convolutional neural networks (CNNs) have demonstrated remarkable success in detecting surface defects, structural anomalies, and quality issues across diverse manufacturing sectors. To enhance defect sensitivity, an attention mechanism is integrated, enabling the model to focus on regions of interest and improve detection accuracy. Furthermore, a feature pyramid network (FPN) module is employed to identify defects at various scales, accommodating the wide range of defect sizes and shapes typically encountered in materials analysis. The model is trained using a combination of binary cross-entropy and focal loss to address class imbalance, with additional localization via smooth L1 loss for spatially identifying defects when required. This architecture, combined with advanced data preprocessing and augmentation, is evaluated using precision, recall, and intersection over union (IoU) metrics, showing promising results in accurately detecting and localizing defects in infrared images. We propose to develop an automatic defect detection system using neural networks in thermography that is usedin quality control and anomaly identification.

Keywords: Infrared Imaging, Machine learning, Thermal images, Convolutional neural networks.





### To estimate the thermo-physical properties of the hidden defects in the materials using ML models

**CP 168** 

THE ABSTRACT

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Infrared imaging has emerged as a powerful tool for theregular inspection of the materials and ranging for the different applications from medical diagnostics to environmental monitoring to defense. Estimating the thermophysical properties of defects using infrared thermography offers several benefits, particularly in quality control. Thermophysical properties include parameters like thermal conductivity, thermal diffusivity, and specific heat capacity etc. Understanding the thermophysical properties associated with the defects allows the early detection of anomalies in materials. This can help prevent further damage and reduce the likelihood of failures. Thermophysical properties of defects can also be used to establish maintenance schedules based on the severity and type of defects detected. This approach helps extend the lifespan of materials and reduces the need for reactive maintenance. Metrics like reflection coefficient can be used to estimate the mismatch between the incident energy and reflected energy. Reflection coefficient is the function of effusivity which depends on product of conductivity, density of the material and specific heat capacity of the material. We propose a method to estimate the properties of the tumors using ML models by predicting the thermo-physical properties of the skintumors. We basically capture the relationship between the skin tumors and temperature distribution of the skin surface using deep learning. Then, model the skin tissue which consists of different layers including tumor, muscle, fat, dermis and epidermis using FEM simulation with the help of COMSOL software using the different thermo-physical properties. Then the deep learning model is used to relate the time-dependent surface temperature with the thermo-physical properties and trained by the numerical simulation data.

Keywords: Infrared Imaging, Machine learning, Thermophysical properties, Reflection coefficient.



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### Impact of LED-Based Heating on Defect Detection in Active Thermography of Metal Samples

**CP 170** 

THE ABSTRACT

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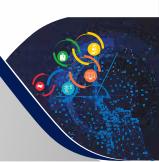
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Active thermography has emerged as a powerful tool within Thermal Non-Destructive Testing and Evaluation (TNDT&E) due to its ability to assess material integrity and structural health without affecting future usability. This technique involves inducing thermal energy into materials and analysing the resulting temperature profiles to detect hidden defects or anomalies. In this study, we explore active thermography's application for evaluating a range of materials, including soft tissues, concrete, and metals, emphasizing its versatility across different material types. Here, we focus specifically on detecting anomalies in metal samples, utilizing LED-based heating sources for thermal excitation. LED-based heating offers several advantages over traditional halogen sources in thermography. LEDs provide rapid heating response, high energy efficiency, extended lifespan, and enhanced safety by emitting less heat into the surrounding environment. These benefits make LEDs a compelling choice for non-destructive evaluation, particularly in scenarios where safety and operational costs are key considerations. This study employs both traditional thermographic methods and pulse-compression techniques to maximize the benefits of LED heating. Pulse-compression techniques, which use modulated signals to improve signal-to-noise ratios, are particularly beneficial in enhancing defect detectability in thermographic evaluations. A qualitative comparative analysis was conducted to assess fault detection performance in metal samples using LED versus halogen heating sources. Different excitation techniques were applied in both time domain and frequency domain analyses. Findings suggest that LED-based heating sources enable comparable, if not superior, detection sensitivity while reducing operational risks and energy costs. Moreover, LED excitation sources facilitated the application of advanced methodologies like pulse-compression thermography, which provides high-resolution thermal images with enhanced defect detection. This study highlights LEDbased active thermography's potential as a safer, more efficient alternative to conventional halogen heating in TNDT&E, supporting its broader adoption in industrial and structural applications.

**Keywords:** Thermal wave imaging, Pulse compression, Optical heating, frequency domain, Time Domain.





### DPAI: Data-Driven Simulation-Assisted-Physics Learned AI For Modelling Heat Diffusion in Voronoi-Based Polycrystalline Materials

**CP 171** 

THE ABSTRACT

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This article introduces a deep-learning algorithm specifically designed to simulate heat diffusion in polycrystalline materials, which are materials composed of numerous crystalline grains. The microstructure of these materials, characterized by their unique grain sizes and orientations, is represented using Voronoi tessellations. These tessellations form the foundation for generating a 2-D CAD model that encapsulates the material's geometry. This CAD model is subsequently used as the primary input for numerical methods employed to solve heat diffusion equations, which is crucial for studying how heat propagates across the material.

In conventional approaches, incorporating the anisotropic nature of these polycrystalline materials into the simulation adds considerable complexity. As a result, traditional finite element (FE) simulations for these tasks often require extensive computational resources and time to deliver accurate results. To address this, the study proposes a Data-driven Physics-Assisted AI (DPAI) model that combines data-driven techniques with physics-informed simulation. The DPAI model is structured as an encoder-decoder architecture with four convolutional long short-term memory (ConvLSTM) cells, enabling it to process spatial and temporal patterns of heat diffusion effectively.

The DPAI model was trained using datasets generated from FE simulations that incorporated varying Voronoi tessellations and a single-point heat source at the center. Through these datasets, the model learned the underlying physics governing heat diffusion within polycrystalline materials. Once trained, the DPAI model demonstrated its ability to simulate heat diffusion across different microstructural scenarios with varying levels of anisotropy, achieving a high level of accuracy while significantly reducing computational time compared to traditional FE methods. This deep-learning approach thus offers an efficient alternative for conducting complex thermal simulations in anisotropic materials, paving the way for faster material design and analysis.

Keywords: Microstructure; ConvLSTM; Voronoi; Polycrystalline; heat diffusion; DPAI



### Multi-Format CT; a concept to improve productivity in Industrial CT systems

**CP 172** 

THE ABSTRACT

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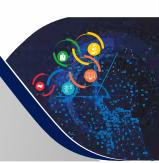
Use of Computed tomography (CT) is seeing a steady increase in many applications in both R&D and Production environment. The main advantage of CT scan is it can give complete insights into an object in a non-destructive manner. The disadvantage of CT is the higher scanning and reconstruction time for a single object. Small objects cover a smaller detector area for imaging while the rest of the detector area is not useful for the CT. M/s Fraunhoffer and M/s X-ray Lab already have a technique for scanning multiple objects at a time called PolyCT to use the complete detector area.

With objects that are smaller in length, multiple of them can be placed one above the other for the CT scan but still the horizontal detector area is empty and cannot be utilized. If multiple objects are placed along the width of the detector the penetration thickness increases when multiple parts come in the path of X ray beam and hence higher energies will be needed. Also, due to the increased effective width, magnification is to be increased and this reduces the system throughput.

This paper is to introduce a novel technique called Multi-Format CT. In this, multiple rotation axes are used for the CT scan to accommodate multiple objects. For long objects that cover the entire height of the detector, three number of objects can be placed adjacent to each other on three different rotation axes. During the CT scan, each rotation axis is rotated independently in a synchronized manner. Reconstruction is performed for all three objects and each object can be separated for analysis. Similarly, the same technique can be used for small length objects wherein multiple of them can be stacked one on top of the other in each rotation axes and CT can be performed. Our proposal is for high throughput applications where there are multiple spindles to accommodate very small objects.

Keywords: Multi-Format CT, Industrial CT, High throughput, Increased productivity





# Complementary Golay Coded Thermal Wave Imaging Scheme for Detection of Sub-surface Corrosion in Metallic Sample

**CP 173** 

THE ABSTRACT

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InfraRed Thermography (IRT) is a widely used non-destructive testing (NDT) technique for assessing material integrity, particularly in detecting hidden corrosion in metallic structures across industries such as aerospace, oil &gas, ship, and power generation. While IRT is favored for its non-invasive nature and realtime thermal data capabilities, its effectiveness in identifying subsurface corrosion can be limited by factors such as noise and insufficient resolution. This paper introduces an innovative approach within IRT known as Golay Complementary Coded Thermal Wave Imaging, designed to enhance the detection of subsurface corrosion. By utilizing Golay-coded pulse compression, this technique significantly improves the signal-tonoise ratio (SNR), which is crucial for distinguishing corrosion-related thermal responses from background noise. The use of complementary Golay codes reduces noise while preserving the thermal signal generated by subsurface corrosion, resulting in higher-resolution thermal images. This enhancement enables more accurate localization and identification of corrosion, even at varying depths or in complex geometries where conventional methods may fail. Comparative analysis with traditional thermographic techniques, such as pulsed thermography (PT) and lock-in thermography (LT), demonstrates that Golay-coded imaging offers superior contrast and detail, particularly for detecting corrosion beneath the surface where traditional methods struggle with resolution and noise interference. The improved clarity and depth specificity provided by Golay-coded thermal wave imaging holds significant implications for critical industrial applications, offering a more reliable and precise approach to corrosion detection. This advancement in IRT capabilities supports safer and more effective monitoring of metal components prone to corrosion, enhancing the accuracy and efficiency of both routine and specialized inspections in industries where material integrity is crucial for safety and performance.

**Keywords:** Thermal wave imaging, Golay Complementary Coded Thermal Wave Imaging, Time Domain, frequency modulated



# Pulse Compression Favorable Thermal Wave Imaging Techniques for Detection of Sub-Surface Corrosion in Metallic Sample

**CP 174** 

THE ABSTRACT

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This article investigates the application of pulse compression-based thermal wave imaging to enhance the sensitivity and resolution of subsurface corrosion detection in metallic materials used in industries such as aerospace, energy, and automotive. While active infrared thermography (IRT) has long been employed for corrosion inspection using conventional excitation techniques, its full potential is often hindered by factors like noise and limited resolution, which can make it difficult to detect fine subsurface defects. Pulse compression techniques, which improve the signal-to-noise ratio and boost the resolution of thermal signals, offer a promising solution to overcome these challenges. The study introduces the InfraRed Image Correlation (IRIC) approach, which processes pulse-compressed thermal data through a matched filter to reconstruct correlation fringes that reveal hidden corrosion patterns beneath the metal surface. By extracting spatio-temporal data, the IRIC method provides a more accurate and detailed reconstruction of corrosion structures, enabling better detection of subtle and often hard-to-spot defects. Additionally, the article compares results from phasegrams generated through time-domain data processing, highlighting the advantages of this post-processing approach. Time-domain analysis enhances the clarity and definition of the correlation fringes, which is essential for detecting small, subsurface flaws that can affect the structural integrity of metallic materials. The time-domain processing significantly improves the resolution and accuracy of thermal Non-Destructive Testing and Evaluation (NDT&E), providing a more reliable tool for assessing corrosion in metal structures. This refined approach has the potential to revolutionize industrial inspections, offering greater precision, reducing the risk of undetected damage, and ultimately improving the safety and longevity of critical infrastructure. The study emphasizes that while pulse compression-based corrosion detection techniques show great promise, their full potential remains largely unexplored and warrants further investigation for widespread industrial application.

**Keywords:** Thermal wave imaging, Pulse compression, frequency domain, Time Domain, frequency modulated

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### Testing and Evaluation of Carbon Fiber Reinforced Polymers using frequency modulated thermal wave imaging

**CP 175** 

THE ABSTRACT

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Infrared non-destructive evaluation is a valuable tool for characterization of wide variety of structural components/materials. It is based on capturing and processing of thermal response over the material to obtain information about its surface and sub-surface features or material inhomogeneities. This paper investigates the anomaly detecting abilities of frequency modulated infrared thermographic technique to assess a carbon fiber reinforced polymer specimen containing artificial defects in the form of blind holes.Infrared non-destructive evaluation (NDE) is a powerful tool for characterizing a wide range of structural materials and components. By capturing and analyzing the thermal response of a material, infrared NDE enables the identification of surface and sub-surface features, as well as material inhomogeneities, without causing any damage to the specimen. This method is highly valuable for assessing the integrity and condition of complex materials used in industries like aerospace, civil engineering, and automotive sectors, where structural reliability is paramount. The focus of this study is on the anomaly-detection capabilities of frequency-modulated infrared thermography, a specialized technique within the infrared NDE family. Frequency modulated involves modulating the frequency of the thermal excitation applied to the material, which provides a detailed thermal response pattern that can reveal subtle variations associated with structural defects. This approach is particularly advantageous for materials like carbon fiber reinforced polymers (CFRPs), which are widely used in high-performance applications due to their strength-to-weight ratio but are prone to defects that may not be easily detectable by conventional inspection methods. In this investigation, frequency modulated is used to examine a CFRP specimen embedded with artificial defects in the form of blind holes, which serve as simulated flaws. The blind holes vary in depth and diameter, providing a controlled environment to evaluate the sensitivity of frequency modulated for detecting subsurface anomalies. The thermal images obtained are processed and analyzed to assess how accurately the technique can identify and characterize these defects. Results from this study highlight the potential of frequency modulated in locating and sizing defects in CFRP materials, suggesting that it could be an effective NDE method for quality control and structural health monitoring in industries where CFRPs are commonly used. This research contributes to advancing infrared NDE techniques for enhanced detection of hidden flaws in composite materials.

**Keywords:** Thermal wave imaging, Pulse compression, frequency domain, Time Domain, frequency modulated



#### A Novel Approach to Frequency Modulated Thermal wave Imaging Data Analysis: Constrained Autoencoder for Enhanced Defect Visualization

**CP 176** 

THE ABSTRACT

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Prabhu Babu<sup>2</sup>, Ravibabu Mulaveesala<sup>1</sup>

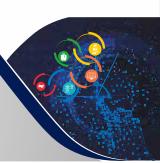
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Non-destructive testing and evaluation (NDT&E) techniques are indispensable tools for ensuring the safety and integrity of materials across various industries. Among these techniques, pulsecompressed frequency modulated thermal wave imaging (FMTWI) in thermal non-destructive testing (TNDT) has gained significant prominence due to its exceptional noise rejection capabilities. However, the highdimensional thermal imaging data generated by FMTWI requires efficient compression without compromising information, to effectively reveal hidden defects within materials. This paper introduces a novel thermography approach leveraging constrained and regularized autoencoders to improve subsurface defect detection in carbon fibre reinforced polymer (CFRP) specimens. Unlike traditional linear autoencoders, the proposed method incorporates specific constraints to enhance the encoding process. These constraints promote noncorrelation of encoded data, weight orthogonality, and unit norm length of weights. These properties, which are not inherent to linear autoencoders, play a crucial role in improving defect detection sensitivity. By incorporating these novel constraints into the autoencoder's cost function, the proposed approach surpasses both linear autoencoders and traditional principal component thermography (PCT) in terms of signaltonoise ratio (SNR) of detected defects. The analysis reveals that noncorrelation of encoded data is the most influential factor in achieving superior defect detection, followed by weight orthogonality and unit norm length constraints. The proposed method offers a promising solution for enhancing the accuracy and reliability of FMTWI based defect detection. By effectively compressing highdimensional thermal data while preserving crucial information, this approach contributes to improved material safety and quality control in various industrial applications.

**Keywords:** Autoencoder, deep learning, frequency modulated thermal wave imaging (FMTWI), non-destructive testing & evaluation (NDT&E).





#### The remnant thickness of the pipeline evaluation using an integrated system of A crawler robot and EMATs

**CP 177** 

THE ABSTRACT

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Determining the remnant thickness of mild steel gas pipelines is crucial to ensure safety, durability, effective corrosion management, and cost efficiency. In this paper, we propose to determine the wall remnant thickness of pipes through internal inspection using Shear Horizontal (SH) guided waves, offering the possibility of rapid inline screening and wall remnant thickness measuring. The current study describes an integrated pipeline inspection system that uses a crawler robot with a platform mounted on it, and this platform contains the EMATs and linkage arms that extend with a linear actuator's aid to support SH-guided wave probes and to minimize the space between the inner pipeline perimeter and the EMATs. A broadband wavelength is generated by taking a range of spacing between EMAT magnets; thus, a broadband frequency could be obtained, and the frequency input range was achieved using a linear frequency-modulated chirp signal. The cutoff property of SH wave modes is utilized to determine the remnant thickness of the pipeline. The EMAT probe transmits and receives SH-guided wave modes propagating in the circumferential direction in two paths, the short path of 300 mm (between probes) and the long path (the rest of the pipe circumference). The 3D Finite Element models and the experiments are presented in detail with analysis in the present article.

**Keywords:** Electromagnetic Acoustic Transducer (EMAT), remnant thickness, Circumferential direction, Shear Horizontal (SH) guided waves, Pipeline inspection.



# Application of NDT Technique for Detecting Weld Joint Defects in Small Bore Connections and Dead Ends in Refinery and Chemical Plant Facilities

**CP 178** 

THE ABSTRACT

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This paper explores the application of a major Non-Destructive Testing (NDT) technique for identifying weld joint defects and health assessment in one of the most challenging areas of refinery and chemical plant facilities: small bore connections and dead ends.

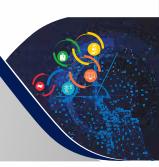
These small-bore connections, commonly welded to main lines through configurations such as half couplings, weldolets, and sockolets, are critical to the overall system integrity. Given that they are typically connected to high-pressure and high-temperature pipelines, any failure in these joints poses a substantial risk, potentially leading to severe incidents. Also, dead ends are facing higher corrosion rates due to the high concentration of contaminants. Ensuring the integrity of these connections, however, has historically been difficult due to their complex geometries and limited accessibility also as per code there is no volumetric NDT method to access the health of weld joints.

In our study, we applied a NDT technique to inspect the weld joints in small bore piping and health assessment of dead ends under operational conditions. This approach allowed us to effectively detect and address potential defects, thereby reinforcing the safety and reliability of these connections. By implementing this technique, we achieved a comprehensive assessment that led to the elimination of critical defects, and proactively planning the repair or replacement which significantly enhancing the integrity of the system.

This presentation will detail the unique challenges encountered during the inspection process and the solutions that were successfully implemented. Our findings offer a practical, accurate method for identifying weld joint defects in small bore piping and assessing the health of dead ends, even during continuous plant operation. This paper aims to be informative, collaborative, and interactive, providing valuable insights for professionals seeking effective inspection solutions for refinery and chemical plant piping.

**Keywords:** Small Bore, Dead ends, NDT technique, Unique solution,





## Ultrasonic Imaging Technique for NDE: Arbitrary Virtual Array Source Aperture using Sign Coherence Factor

CP 179

THE ABSTRACT

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In this paper, we propose the ultrasound imaging method arbitrary virtual array sources aperture (AVASA) using signal sign coherence (SC) information to inspect thick, highly attenuating structural components and enhance image resolution. The AVASA-SC employs phased array (PA) parallel transmission to focus beamforming at multiple virtual sources, improve the signal-to-noise ratio (SNR) of received A-scan signals, and record the reflected signals with all the array elements. The high-resolution imaging is reconstructed on the reception by an AVASA beamformer that virtually focuses on each point in the inspection region through the coherence summing of the signal sign bit, reducing image processing time.AVASA effectively images thicker structures by focusing the ultrasound beam at virtual sources through exciting parallel transmission. However, in AVASA, the SNR of deeper reflectors can be reduced due to signal amplitude-based image reconstruction. Therefore, AVASA-SC uses the instantaneous signal sign bit of the AVASA beamforming aperture data to create imaging. Comparing AVASA-SC's defect SNR and imaging resolution for deeper-located defects, two test samples (one with known defects, one with unknown) were scanned using AVASA and full matrix capture-total focusing method (FMC-TFM) techniques. AVASA-SC significantly improves image resolutions, enabling enhanced defect characterization. The AVASA-SC method's effectiveness was demonstrated by inspecting a thick structural component with unknown defects. AVASA-SC revealed more defects and significantly improved SNR compared to standard beamforming algorithms. In AVASA-SC, defects located farther from the transducer exhibited higher intensity due to the increased ultrasound energy transmitted into the medium. AVASA-SC effectively suppresses noise levels in the image, leading to improved SNR for deeper defects.

**Keywords:** Phased Array, Ultrasound Imaging, Coherence Factor, Virtual Source, AVASA, FMC, TFM, Beamforming.



Analysis of DCSP-TIG weldment of aluminum alloy AA2219 by phased array ultrasonic technique (PAUT) with and without flushing of weld beads for circumferential seam welds of propellant tankages for launch vehicles

**CP 180** 

THE ABSTRACT

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The aluminum alloy AA2219 (Al-Cu alloy) is widely used in the fabrication of propellant tankages and launch vehicle structure owing to high strength-to-weight ratio, excellent weldability, formability and good resistance towards stress corrosion cracking. DCSP Tungsten inert gas (TIG) welding process is widely used for joining shell panels and petals of propellant tankages for launch vehicle programmes of ISRO. In the weld zone additional thickness is observed as weld reinforcement by adding filler wire as part of the multiple passes during welding process which results in formation of top crown and under bead on the weldment. Non-destructive testing techniques viz. X-ray radiography, dye penetrant testing, conventional ultrasonic testing as well as phased array ultrasonic testing is carried out as part of clearance of weld joints. Planar defects like lack of fusion, cracks, etc are detected more accurately in ultrasonic testing as compared to other NDE techniques. As of now, conventional ultrasonic testing is carried out at rework and overlap zones to identify planar defects as part of weld acceptance. Phased array ultrasonic testing (PAUT) is being included as a new NDE technique for propellant tankages for fusion welds. In relation to these plate level specimens with 9 mm thickness are welded using DCSP-TIG welding technique and PAUT trails are being done for the same. PAUT scan plan programme is prepared including heat affected zone with help of Zetec TOPAZ16 system for the TIG welded joints. Weld bead edge indications are observed and recorded in PAUT. These indications are eliminated by bead flushing. These indications are also confirmed by conventional ultrasonic testing. PAUT resulted in weld bead indications more than acceptable level, if carried out without flushing of weld bead. Hence, it is suggested to carry out PAUT only after bead flushing for top bead and under bead for TIG welded joints. Detailed experimental analysis with PAUT is carried out as part of this paper for 9 mm thickness DCSP-TIG welded AA2219 alloy with and without flushing of weld beads.

**Keywords:** Phased Array Ultrasonic Testing (PAUT), Tungsten inert Gas (TIG), Conventional Ultrasonic Testing, Indications, AA2219.



#### **Tethered Intelligent Pigging**

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CP 182

THE ABSTRACT

NDT Technologies (P) Ltd has been at the forefront of providing advanced Non-Destructive Testing solutions since 2002, specializing in advance custom based robotic solution and other inspection technologies for critical industrial assets like Boiler, Economizer & Heater coils.

**Application:** In the operation of utility boilers, economizer and superheater tubes play a critical role in preheating fluids and maintaining energy efficiency. Failure in these tubes, such as cracks, erosion, or pitting, can significantly impact boiler performance, resulting in costly downtime and safety hazards. Regular and effective inspection of these coils is essential to ensure the ongoing safe and efficient operation of boilers.

**Current Solution:** Traditional NDT methods like spot ultrasonic testing (UT) and electromagnetic testing (ET) face significant limitations when inspecting boiler coils, especially in terms of accessibility and the ability to comprehensively assess the condition of long, curved, and complex tube structures.

**NDTT Solution:** To address these challenges, NDTT has developed an innovative Tethered Intelligent Pigging (TIP)that integrates Immersion Ultrasonic Testing (IUT), ET, and Remote Visual Inspection (RVI).

- 1. Inspects tubes of 30mm to 100mm diameter
- 2. Capable of inspecting tubes up to 100 meters in length.
- 3. Capable of navigating multiple U bends as tight as 0.8D, allowing thorough inspections even in complex geometries.
- 4. ET: is reliable method for detecting isolated defects such as pitting, cracking, and other forms of degradation. Multiple frequencies are used. Minimum Cleaning is required.
- 5. HD camera offers high-definition visuals of the tubes
- 6. 6nos Ultrasonic probes are used for Corrosion mapping.
- 7. Tethered Technology: Enables real-time inspectionand ensuring location accuracy for defect identification.
- 8. Requirement: two cuts in coils & continuous water supply similar to smart UT pigging

#### **Conclusion:**

The TIP developed by NDTT combines IUT, ET, and RVI into a unified solution that overcomes the limitations of traditional NDT methods. This system is specifically designed for the inspection of boiler and furnace coils, ensuring 100% circumferential coverage and providing accurate, real-time monitoring for the detection of a wide range of defects. By enhancing the reliability of boiler tube inspections and reducing downtime, this advanced technology plays a key role in maintaining the safety and efficiency of industrial boiler systems.

Keywords: Pigging, Economiser coils, Tethered Intelligent Pigging



#### Phase Space Dissimilarity Measures of Nonlinear Vibration Responses for Detection of Subtle Damages in Concrete Structures

**CP 183** 

THE ABSTRACT

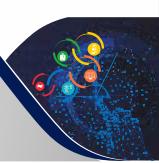
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Reinforced concrete structures, particularly in the early stages of damage, exhibit nonlinear vibration responses due to the softening of concrete as cracks begin to develop. This nonlinearity is most prominent during the initial stages of damage, where the breathing-crack mechanism governs the behavior of the structure. Recognizing these nonlinear features is essential for identifying subtle damage in large concrete structures. This study investigates the use of phase-space dissimilarity to detect early-stage damage in a reinforced concrete bridge girder-deck system. Experimental simulations of damage were performed by applying monotonically increasing static loads at different levels, with vibration responses measured using accelerometers placed at various locations on the structure. The analysis focused on extracting key nonlinear features, particularly changes in phase-space topology, which were found to be highly sensitive to subtle damage. Even in the presence of inherent material nonlinearity, damage-induced nonlinearity became the dominant factor as the damage progressed, and significant changes in the phase-space portrait can be observed. The study demonstrated that, unlike traditional modal analysis that assumes linearity, phase-space analysis can distinctly capture the nonlinearities introduced by structural damage without requiring baseline data. Dissimilarity features derived from time-series analysis of acceleration, velocity, and deflection responses effectively identified damage initiation and progression, particularly at low damage levels. The changes in phase-space topology proved to be an efficient nonlinear damage index, capable of distinguishing between structural and material nonlinearities. These findings suggest that phase-space dissimilarity is a promising tool for early damage detection and real-time monitoring of weakly nonlinear systems such as concrete structures. By providing a baseline-free method for damage assessment, this approach can enhance the effectiveness of structural health monitoring, enabling early identification of crack initiation and propagation, and thus improving the safety and reliability of civil infrastructure.

**Keywords:** Concrete structures, non-linear vibration; Breathing crack; phase space topology; dissimilarity indices





### Super-Resolution Ultrasonic Imaging of Biological Tissues Using Structured Channel Metamaterial Lenses

**CP 184** 

THE ABSTRACT

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Ultrasonic imaging systems are extensively employed in biomedical applications due to their inherent advantages, including being non-ionizing, safe for biological tissues, cost-effective, and capable of significant penetration depths. Despite these benefits, achieving high-resolution imaging beyond the Rayleigh diffraction limit has remained a formidable challenge, restricting their ability to visualize subwavelength features crucial for detailed diagnostics. Recent advancements in the field of acoustic metamaterials, particularly the development of innovative metalenses and hyperlenses, have paved new pathways to surpass this limitation. These metamaterials leverage the ability to manipulate acoustic waves, enabling super-resolution imaging capabilities effectively. In this study, we explore the application of metalenses for enhancing ultrasonic imaging resolution, with a specific focus on their utility in biomedical diagnostics. To mimic the acoustic properties of human soft tissues, we usetofu as a tissue-mimicking materials. Within the tofu, which can replicate acoustic properties of human soft tissue, we embedded subwavelength discontinuities modelled as cylindrical metallic rods. By integrating a structured channel metamaterial, we amplified evanescent waves, which are typically attenuated and lost in conventional imaging systems. These amplified waves were coupled through a waveguide connected to an ultrasonic transducer, achieving super-resolution imaging down to one-third of the operating wavelength, which is beyond the Rayleigh diffraction limit. The results of our experiments demonstrate the feasibility of using metalenses to achieve ultra-fine resolution in imaging biological tissues. This breakthrough holds significant potential for transforming ultrasonic imaging into a powerful tool for high-precision medical diagnostics, offering new opportunities for non-invasive, high-resolution imaging in clinical settings and advancing research in biomedical imaging technologies globally.

Keywords: Super-resolution imaging, Metalenses, Evanescent waves



### Assessment of Localised Material Nonlinearity in Isotropic Media Using Non-Collinear Wave Mixing

**CP 185** 

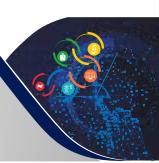
THE ABSTRACT

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The wave mixing technique has emerged as a highly promising method for characterizing material nonlinearity. This technique effectively avoids unwanted harmonic components that are typically induced by instrumental systems, ensuring more accurate results. Furthermore, the spatial selectivity feature of the generated combined harmonics allows for localized monitoring of material nonlinearity in specific regions of interest. This study presents a numerical model that investigates the interaction of two non-collinear shear waves, which generate a longitudinal wave at the sum harmonic frequency in a homogeneous, isotropic medium. The local material nonlinearity is defined using Murnaghan's Third Order Elastic Coefficients, which characterize the material's response to wave interactions. A phased excitation approach is employed in this model to excite and steer the primary waves to the intended mixing zone. The resulting sum harmonic wave's amplitude and directivity are monitored to study how variations in material nonlinearity affect its characteristics. An immersion nonlinear ultrasonic test setup was carefully assembled using commercially available components, and the numerical model results were validated with an Aluminium alloy sample, thereby confirming the reliability of the proposed method. The findings from the validated numerical model highlight the potential of wave mixing as an effective and localized method for assessing material nonlinearity. This technique provides an innovative approach for more precise material characterization, enabling focused analysis of nonlinearity in specific regions of a material. By facilitating detailed and localized evaluation, wave mixing can play a key role in advancing both the theoretical and practical aspects of materials testing, making it an invaluable tool for various industries.

Keywords: Nonlinear Ultrasonics, Wave Mixing, Numerical Modelling





#### Fuzzy Logic-Based Computational Analysis of Ultrasonic NDT Data for Accurate Failure Prediction

**CP 186** 

THE ABSTRACT

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Non-destructive testing (NDT) techniques, particularly ultrasonic testing, are widely employed for detecting defects in materials and predicting potential failures in structural components. However, the interpretation of ultrasonic data can be challenging due to the inherent noise, variability, and complexity of the signals. This study presents a fuzzy logic-based computational framework for the analysis of ultrasonic NDT data aimed at enhancing the accuracy of failure prediction in materials and structures. Fuzzy logic, known for its ability to handle imprecision and uncertainty, is integrated into the analysis pipeline to process ultrasonic signals, extract critical features, and make informed predictions about the likelihood of failure.

The approach begins by preprocessing the raw ultrasonic signals to eliminate noise and enhance the quality of the data. Features such as signal amplitude, frequency, and time-of-flight are extracted and normalized to form the input parameters for the fuzzy logic system. The fuzzy inference system (FIS) uses these parameters to evaluate the condition of the material and predict failure modes. Various membership functions are employed to model the uncertainties associated with the data, while fuzzy rules are designed to correlate the extracted features with known failure criteria.

To validate the proposed method, it is tested on a range of ultrasonic datasets obtained from real-world structural components. The performance of the fuzzy logic model is compared with traditional analytical methods and machine learning-based techniques in terms of prediction accuracy and reliability. The results demonstrate that the fuzzy logic-based approach significantly improves the precision of failure predictions, offering a more robust and adaptive solution for real-time monitoring and decision-making in asset management. This work highlights the potential of fuzzy logic in addressing the challenges of ultrasonic NDT data analysis and emphasizes its applicability in predictive maintenance and failure prevention in industrial applications

Keywords: Ultrasonic Testing, Fuzzy Logic, Failure Predication, MATLAB, Data processing.



### Optimization of Eddy Current Testing Data Using Bio-inspired Algorithmsfor Enhancing Automation Systems

**CP 187** 

THE ABSTRACT

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Eddy Current Testing (ECT) is a widely employed non-destructive testing (NDT) technique for detecting surface and subsurface defects in conductive materials. However, interpreting ECT data can be challenging due to the presence of noisy, high-dimensional signals. This paper investigates the application of Particle Swarm Optimization (PSO) to optimize ECT data, with the aim of improving the accuracy and efficiency of defect detection in industrial automation systems. By utilizing the PSO algorithm, this study focuses on enhancing feature extraction, noise reduction, and classification tasks in the analysis of ECT signals. The proposed method demonstrates how PSO can intelligently fine-tune model parameters, optimizing both sensitivity and specificity in defect detection algorithms. Experimental results validate the effectiveness of the PSO-optimized ECT system, showing significant improvements in defect detection and characterization. These advancements contribute to the development of more reliable and automated inspection systems in industries such as aerospace, automotive, and manufacturing. This work presents a robust solution for automating non-destructive testing (NDT) processes, specifically focusing on enhancing defect detection accuracy and advancing predictive maintenance strategies. By optimizing Eddy Current Testing (ECT) data analysis, the proposed approach significantly improves the identification and characterization of defects, ensuring more reliable and efficient inspection systems. The integration of advanced optimization techniques, such as Particle Swarm Optimization (PSO), enhances model sensitivity and specificity, leading to better performance in industrial automation systems. This innovation pushes the boundaries of quality assurance, strengthening inspection capabilities across diverse sectors such as aerospace, automotive, and manufacturing. This work provides a robust solution for automating and enhancing the accuracy of NDT processes, pushing the boundaries of quality assurance and predictive maintenance in various sectors

Keywords: Eddy Current Testing, Particle Swarm Optimization, MATLAB, Data processing.





## In-Situ Stress Evaluation of Pre-stressedConcrete and Masonry Structures

CP 188

THE ABSTRACT

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Most of the critical civil engineering structures, in particular bridges, are constructed using reinforced/prestressed concrete as structural material. These structures undergo distress with time due to environmental and other unfavorable operating conditions. It is well known that the time dependant phenomenon such as creep and shrinkage of concrete also reduces prestressing force over time. Thousands of concrete bridges presently in operation worldwide are in need of rehabilitation through major works of repairs. In the future, the rehabilitation of existing structures will constitute an exceptionally large field of operation that will extend for many years. Timely retrofitting measures help to reduce damages and improve service life. In order to assess the safety and serviceability and to take a decision about the possible repair measures to rehabilitate the distressed concrete structures, it is necessary to estimate the existing level of stress. Assessing the existing stress of prestressed concrete structures in service is fairly a difficult task and the researcher is often faced with lack of actual design/construction information and environmental service conditions. It is first necessary to generate scientifically and systematically required data relating to the existing level of prestress, in order to take a decision about the residual strength and possible repair measures to rehabilitate the distressedprestressed concrete members. Similarly in-situ stress evaluation in masonry structures is very much essential in preserving our cultural heritage structures.

For assessing the existing stresses on distress prestressed concrete structures concrete core trepanning technique has been developed and for masonry structures flat jack technique is used for in-situ stress measurement. Laboratory studies were conducted to evaluate the reliability of concrete core trepanning technique and flat jack technique. Case studies of assessment of residual prestress in prestressed concrete structures using core trepanning technique and evaluation of stresses in masonry structures are presented and discussed. Using this concrete core trepanning technique and flat jack technique, it is possible to estimate the probable value of existing stresses with a high degree of reliability in prestressed concrete members and masonry structures. This will go a long way for designer to design suitable rehabilitation measures.

**Keywords:** in-situ stress, prestressed concrete structures, masonry structures, flat jacks.



#### Image-Based Correlation Technique for Characterization of Fracture Related Properties of Engineered Concrete

**CP 189** 

THE ABSTRACT

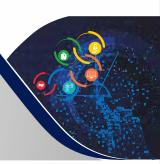
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Initiation of crack in any material primary depends upon its fracture related characteristics. In a quasi-brittle material like concrete, the fracture phenomenon is governed by a zone called 'fracture process zone (FPZ)'. This FPZ is a region near the crack tipwhich consists of a largeamount of micro-cracks whereplastification takes place progressively. The presence, geometry and disposition of FPZ govern the mechanical characteristics of concrete. Hence, it becomes necessary to characterize the FPZ and determine the fracture energy in order to get a holistic understanding of concrete. However, this process is not straight-forward and cannot be obtained through conventional sensors/techniques when the investigations are done in lower length-scale.

In this regard, an attempt has been made in this study to determine the size of FPZ of concrete using non-contact, image-based correlation technique (DIC technique). Digital images of the specimen are captured while carrying out fracture test on notched prism specimensusing a high precision, low capacity UTM which are then analyzed using correlation algorithms to obtain the displacement/strain field. Further, a framework (including the procedure for specimen preparation, experimental investigation and processing of images) has been established in order to estimate the size of FPZ using this strain field. The framework is then extended to determine the fracture characteristics of concrete engineered with polymeric fibers which develops both the mechanical and chemical bond with concrete. The influence of fibers on the crack characteristics such as crack initiation, branching, propagation and alteration of the size of FPZ is evaluated in detail. The findings of this study will help in gaining in-depth information about the fracture characteristics of engineered concrete and thus lead towards efficient design of the same.

**Keywords:** Digital Image Correlation Technique; Fracture Process Zone; Crack Branching; Fiber incorporated concrete.





### Comprehensive Evaluation of Austenitic Stainless Steel Weld Indications in Ultrasonic Testing using advance NDE Techniques

**CP 190** 

THE ABSTRACT

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Inspection of Austenitic Stainless Steel welds using conventional Ultrasonic Testing (UT) poses significant challenges due to factors such as high attenuation, anisotropic nature, beam skewing, and elevated noise levels, which can create confusions in distinguishing real and false indications during evaluation and disposition. The ASME code acknowledges these difficulties and suggests methods to identify and document such indications in a structured sequence of investigation at a macro level leaving majority of sequence of operation at the discretion of NDT level III. While POD of established ultrasonic testing of stainless steel isimportant, measured to reduce False Call Rate also need to be addressed. This often leads to ambiguity in ultrasonic testing of SS welds, thus majority of manufacturers try to avoid UT on SS welds. This paper presents ultrasonic indications observed on single-side full penetration stainless steel weld. It also discuss on the care to be taken while confirming the nature of these indications. A multi-technique approach was employed, including longitudinal angle beam UT, radiographic testing (RT), and advanced phased array ultrasonic testing (PAUT) employing advanced probes such as DLA and DMA. Special mockups simulating the actual weld configurations and sectioning be required for further investigation. Detailed analysis of the location and nature of indications and the response of different UT probes and techniques need to be performed. Insights into optimizing ultrasonic techniques adopting advanced phased array probes for Austenitic Stainless Steel welds thus enhancing the accuracy and reliability of inspection outcomes for similar materials in manufacturing are also discussed.

Keywords: DLA, DMA (Dual Matrix Array), Anisotropy, stainless steel, GTAW, SMAW, SAW



# Inspection of 10" LPG Transfer Pipeline (Non-Piggable) Using High Resolution Ultrasonic Inspection Pipeline Integrity Gauge (ILI PIG)

**CP 191** 

THE ABSTRACT

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As per OISD-STD-130, cross-country pipelines must undergo comprehensive inspection every five years. Accordingly, an In-line Inspection of the 10" LPG Transfer (Non-Piggable) Pipeline was conducted using the advanced Pipeline Surveyor system, which utilizes high-resolution ultrasonic wall thickness measurement to detect geometric and metal loss features.

This 3.7 km pipeline, commissioned in 2004, connects CPCL LPG Bulk Storage to the Bottling Plant in Amullaivoyal, North Chennai. Due to its complex geometry and absence of PIG launching/receiving facilities, the pipeline has remained non-piggable since commissioning. To assess its condition, particularly the underground 1.1 km section, ultrasonic testing was employed for intelligent pigging using this advanced Tool (which can navigate in the non-piggable line).

In-line ultrasonic inspection is performed utilizing a bidirectional inspection tool. The inspection tool is equipped with an ultrasonic measuring head containing one ultrasonic transducer (sensor) and a rotating mirror. The tool transmits the "raw" ultrasonic measurement data through fiber optic cable to the data acquisition system, which records and displays the data on-line.

The 10" LPG transfer pipeline underwent thorough preparation, including flushing to remove hydrocarbons and the installation of temporary pig traps and fittings. A pigging operation confirmed pigability and removed residual debris using medium to high-density foam pigs. Post-cleaning, a dummy tool validated the pipeline's readiness for ultrasonic testing (UT). The UT inspection was conducted with the Pipeline Surveyor Helix tool, and results were transmitted in real-time. Final cleaning and dewatering followed, along with the retrieval of stuck pigs. The final report documented anomalies and highlighted critical issues for pipeline integrity and safety

Keywords: In-line inspection, Cross-country pipeline, Non-piggable, Ultrasonic testing





# Review and Comparison of NDT Methods for Wind Turbine Blade Inspection: A Comprehensive Overview

**CP 192** 

THE ABSTRACT

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The wind energy industry continues to evolve and improve, with larger and more efficient turbines being developed and the cost of wind energy decreasing. This progress has led to wind energy becoming increasingly cost-competitive with fossil fuels in many regions around the world. Overall, the wind energy sector has been consistently growing and is expected to continue playing a vital role in meeting the world's energy demand in a sustainable and environmentally friendly manner. To continue this development, wind turbines need to perform efficiently andreliably. Blades are a critical component of wind turbine systems. However, they are prone to damages caused by complexuneven loading, foreign objects including atmospheric events (thunder, rainfall, hailstorm, snow etc.)that can result in catastrophic failure, and maintenance costs can be high. Damages or defects on wind turbine blades not only decrease the lifespan and power generation efficiency of the turbine, but also increase monitoring errors, safety risks, and maintenance expenses. Therefore, timelydetection of damages on wind turbine blades is crucial for avoiding failure, planning maintenance, and ensuring the sustainability of wind turbines. This study presents a comprehensive review of non-destructive techniques for detecting damage on wind turbine blades, including methods based on strain measurement, acoustic emission, ultrasound, vibration, thermography, shearography, and robotic solutions. The work introduces the current state of wind energy across the globe, wind turbine blade configuration, typical damages to wind turbine blades, followed by an explanation of the detection principles, advantages, and limitations of the techniques. Finally, the study presents a comparative analysis of potential research directions for damage detection techniques on wind turbine blades and the conclusions. It is anticipated that this comprehensive analysis will provide guidelines for practical wind turbine blade inspections and suggest research prospects for damage detection techniques.

Keywords: wind turbine blade, damage detection, visual inspection, composites, NDT.



### Integration of Robotics Platforms for NDE: Enhancing Situational Adaptability

**CP 193** 

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THE ABSTRACT

This paper showcases the integration of diverse robotics platforms for Non-Destructive Engineering (NDE) applications within the oil and gas industry, focusing on enhancing situational adaptability. Drawing from practical experience, we highlight the effectiveness of robotics in performing precise Inspections and Maintenance tasks in hazardous environments, thereby improving safety and operational efficiency of executing NDE/Inspection tasks in the field. We discuss the technical concepts of platform development, including modular design and interoperability. Modular design allows for the easy replacement and upgrading of components, ensuring that the robotic systems can be tailored to specific Inspection and supporting Maintenance tasks. Interoperability ensures that different robotic platforms can work together seamlessly, sharing data and coordinating actions to achieve optimal results. Advanced control systems provide the necessary precision and reliability for complex NDE tasks.

The integration of specialized payloads, such as high-resolution cameras, ultrasonic sensors, and other inspection probes, is explored to demonstrate their role in enhancing the capabilities of robotic inspection systems. These payloads enable the robots to gather detailed data, which is crucial for accurate assessment and decision-making in NDE processes. The resulting integrated systems offer improved performance, flexibility, and reliability, providing significant advantages over traditional inspection approaches. These systems can adapt to various operational scenarios, from routine inspections to emergency responses, ensuring that the oil and gas infrastructure is maintained in optimal condition.

This study aims to provide valuable insights for industry professionals and researchers interested in developing and implementing advanced robotic solutions for NDE in the oil and gas sector. By leveraging the strengths of diverse robotics platforms and integrating specialized payloads, we can achieve more efficient, safe, and effective NDE operations.

Keywords: NDE, robotics, payloads, situational adaptability, platform development, inspection





# Review of Non-destructive Techniques for in-Service Inspection, Repair, and Continuous Monitoring of FRP Components

**CP 194** 

THE ABSTRACT

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Non-metallic materials have gained popularity in the oil and gas industry due to their light weight, resistance to corrosion, and minimal maintenance needs, making them the preferred option for piping, tanks, and vessels where the above advantages offer a competitive edge over other material choices. However, there are no established methods for evaluating the remaining lifespan of these components after they are placed in service. Although there are methods such as visual inspection, pressure testing and use of destructive testing techniques, there is no non-destructive testing (NDT) with linked to Fitness for Service (FFS) methodology for assessment of the remnant life of non-metallics. This combination of NDE and FFS is critically needed provide asset integrity assurance for continued safe operation nonmetallic equipment, especially for going beyond the design life.

In this study, we have reviewed the state-of-the-art NDT methods that are available or may be further developed for use with FFS to assess the integrity and remaining life of in-service nonmetallic equipment. The review also considers non-metallic components' physical, chemical, and mechanical properties, as well as of the degradation mechanisms that may compromise their integrity.

Keywords: Non-metallics inspection, remaining life assessment, material inspection, NDT.





# Experts in Ultrasound Inspection

Phased Array, FMC/TFM, Air-Coupled UT, Multi-Channel, Advanced Imaging Technologies



# PIONEER

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 The Phased Array Company





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Waygate Technologies, a Baker Hughes business, is an industrial inspection solutions provider and the world leader in Non-Destructive testing (NDT) ensuring safety, quality and productivity. We combine more than 125 years of experience and a collection of heritage brands including Krautkrämer, phoenix | x-ray, Seifert, Everest and Agfa NDT. Today, hundreds of brands in the automotive, aviation, space exploration, electronics, energy, battery and additive industries trust our technologies. We drive digital transformation through a broad portfolio of award-winning solutions in industrial radiography and computed tomography (CT), remote visual inspection (RVI), ultrasound (UT), eddy current, and robotic inspection.

Headquartered in Germany, Waygate Technologies is part of the Industrial & Energy Technology segment of Baker Hughes (NYSE: BKR). Inspection starts here: waygatetech.com

**E WIDENT** 

In 2022, Olympus Corporation spun off its Scientific Solutions Division, including its life science and industrial solutions businesses, to establish a new company called Evident. Although our name is different, our expertise, manufacturing capabilities and commitment to our customers, which defined us over the past 100 years, remain unchanged.

At Evident, we are guided by the scientific spirit—innovation and exploration are at the heart of what we do. Committed to making people's lives healthier, safer and more fulfilling, we support our customers with solutions that solve their challenges and advance their work; whether it's researching medical breakthroughs, inspecting infrastructure, or exposing hidden toxins in consumer products.

Evident's industrial solutions range from microscopes and videoscopes to nondestructive testing equipment and X-ray analyzers for maintenance, manufacturing and environmental applications. Backed by state-of-the-art technologies, Evident products are widely used for quality control, inspection and measurement.

In life science, Evident empowers scientists and researchers through collaboration and cutting-edge solutions. We're dedicated to meeting the challenges and supporting the evolving needs of our customers, continuing to advance a comprehensive range of microscopes for pathology, hematology, IVF and other clinical applications as well as for research and education. For more information, visit EvidentScientific.com.





Growth is Life

Reliance is India's largest private sector company, with a consolidated revenue of INR 10,00,122 crore (US\$ 119.9 billion), cash profit of INR 1,41,969 crore (US\$ 17.0 billion) and net profit of INR 79,020 crore (US\$ 9.5 billion) for the year ended March 31, 2024. Reliance's activities span hydrocarbon exploration and production, petroleum refining and marketing, petrochemicals, advanced materials and composites, renewables (solar and hydrogen), retail and digital services.

Currently ranked 86th, Reliance is the largest private sector company from India to be featured in Fortune's Global 500 list of 'World's Largest Companies' for 2024. The company stands 45th in the Forbes Global 2000 rankings of 'World's Largest Public Companies' for 2023, the highest among Indian companies. Reliance has been recognized in Time's list of the 100 Most Influential Companies of 2024, marking the only Indian company to have achieved this honor twice. Reliance is the top-ranked Indian company and the only one in the top 100 on Forbes' 'World's Best Employers' 2023 list. Additionally, it is featured among LinkedIn's 'Top Companies 2023: The 25 Best Workplaces To Grow Your Career In India. www.ril.com

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Larsen & Toubro Ltd: A Legacy of Excellence

Larsen & Toubro Ltd (L&T) is a Indian multinational conglomerate with a rich legacy of over eight decades. Founded in 1938 by two Danish engineers, Henning Holck-Larsen and Søren Kristian Toubro, L&T has grown into one of India's largest and most respected companies.

With a diverse portfolio spanning engineering, construction, manufacturing, and services, L&T has played a pivotal role in shaping India's infrastructure landscape. From iconic landmarks to critical infrastructure projects, L&T's expertise has left an indelible mark on the nation's development.

L&T Heavy Engineering, a key business vertical, is a leading manufacturer of critical equipment and systems for the energy, With a strong focus on digitalization, innovation, quality, and customer satisfaction, L&T Heavy Engineering has established itself as a trusted partner for global customers.

Another significant IC of L&T, Precision Engineering and Systems involved in ship building, aerospace and defence with a strong focus on latest technology and reliable systems development.

As L&T continues to evolve and grow, its commitment to excellence, innovation, and nation-building remains unwavering.







We at FUJIFILM India take this opportunity to introduce ourselves as 100% subsidiary of M/s FUJIFILM Corporation, Japan which was established in the year 1934 as a photographic film manufacturer.

FUJIFILM as one of the world's largest photographic and imaging Company had earned the confidence of Indian customers by delivering high performance & quality product backed up with truly reliable after sales service capacity.

Fujifilm's imaging expertise goes far beyond photography. Beginning in 1981 with successful inception of "Fujifilm Digital Radiography" technology in Medical Radiography equipment's the same was replicated in Industrial Radiography equipment's in 2006. So our Industrial Product Division largely caters to NDT Industry primarily with radiography application that uses Xrays to reveal defects in manufactured products or structures. Also has simultaneously adopted to the evolving needs of the Digital Radiography requirements with sophisticated digital equipment's like Dynamix HR2 systems, FXR & FXR pad system.

Our Industrial Dynamix System technology is built with Advanced emulsion science, computerized and digital imagining processes that assures quality for industrial X-ray applications along with Highest image quality system to meet versatile needs of the NDT Industry. Fusion of Fujifilm's advanced Coating and Image processing technologies used in image reader, software and IP realizes images with finest possible quality expected in digital imaging. On the whole our Industrial Radiography digital solutions has world's top class\* high spatial and density resolution with Excellent signal to noise ratio (SNR) that produces superb image quality.



TWI India Pvt. Ltd. is a subsidiary company of TWI Ltd. (TWI), a world-leading research and technology organization. TWI provides impartial technical support in Welding, Joining, Materials Science, Structural Integrity, NDT, Surfacing and Packaging. Services include Generic Research, Confidential R&D, Technical Information, Technology Transfer, Training, and Qualification.

As the world's largest training organisation in Welding, Welding Inspection and Non-Destructive Testing, each year over 20,000 participants in more than 60 countries benefit from our expertise. Our courses and examinations are designed to service all key industry sectors, including Oil and Gas, Aerospace, Construction, Power and Automotive, with all courses supported by internationally recognised certification.

In India, other than delivering Training and Examinations towards internationally recognized certification in Welding, Painting, Non-Destructive Testing and Plant Inspection, we offer Bespoke Training Solutions both for industrial member and non-member organizations.





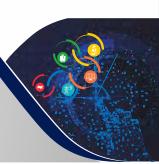
inspection. We achieve this by providing world-class inspection products and services across various industries, leveraging robotics and automated application-based systems. Our unwavering focus is on exceeding customer expectations and delivering innovative solutions. Our journey began in 2002 as a partnership specializing in non-destructive testing (NDT) equipment sales and representing international companies. Since then, we've continuously expanded our offerings:

- 2006: Ventured into 24/7 remote visual inspection services.
- 2012: Launched our project division, starting with robotic pipeline inspection for MCGM.
- 2013: Undertook our first EPC contract for pipeline rehabilitation using a machine with strip lining technology.
- 2015: Launched in-house R&D department to focus on cutting-edge inspection technologies and solutions.
- 2023: Supplied the first Made-in-India RDSO approved Ultrasonic Railway Wheel Inspection system.

Today, NDT Technologies (P) Limited is a leading provider of advanced and specialized NDT products and services. We've also pioneered application-based solutions since 2002.

- 2. Ultrasonic Immersion Testing System
- 3. Ultrasonic Flaw Detector
- 4. UT Phased Array System
- 5. Ultrasonic Thickness Gauge
- 6. High-resolution imaging ultrasonic phased array system
- 7. Crack Depth Gauge
- 8. Hardness Tester
- 9. Coating Thickness Gauge
- 10. Video scope
- 11. Robotic Cameras
- 12. Magnetic Particle Inspection and Accessories
- 13. Radiation Resistant Underwater Camera
- 14. Wire Rope Tester
- 15. Eddy Current Sorting System
- 16. Portable Eddy Current Array







Met-L-Chek® is an approved manufacturer, qualification laboratory, and supplier of liquid penetrant inspection materials under SAE QPL AMS 2644 by the United States Air Force Research Laboratory's Materials and Manufacturing Directorate at Wright-Patterson Air Force Base.

Liquid penetrant and magnetic particle materials Certified to meet the requirements of AMS, ASTM, ASME, ISO, DoD specifications Trusted by Pratt & Whitney, General Electric, Rolls-Royce, Boeing, Consolidated Precision Products, Mistras, and Precision Castparts Corp

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Electronic & Engineering Company (I) P. Ltd. (EECI) has been manufacturing and supplying Non-Destructive Testing (NDT) solutions since 1958 having DSIR approved R & D centre and NABL approved Calibration lab. We believe in:

- Focusing on our customers & providing ideal solutions for their applications.
- Continual innovation to produce cutting-edge products.
- Superior after sales services and supporting our customers.
- Maintaining a high threshold for the quality and performance of our solutions for uninterrupted operations.

EECI has successfully supplied innovative solutions to important industries such as:

- Steel Aerospace Automotive Railways
- Defence Oil & Gas Nuclear Heavy Engineering Industry
- Renowned Educational Institutes

# EECI manufactures wide range of Products:

- Portable Ultrasonic Flaw Detector & Ultrasonic Thickness gauges
   Ultrasonic Transducers & Reference block
   Automated Ultrasonic System for Pipe, Plate, Tube, Bar and Components
- Automated Eddy Current Sub-System
   Magnetic Particles Test Equipment: Yokes, Bench Units,
- Radiation Safety Devices Radioactive Isotopes Supply
- EECI's world renowned principles are:
- M/s QSA Global Inc. U.S.A (For Industrial Radiography Equipment)
- Institute Dr. Foerster GmbH Co. KG (Germany) (For Eddy Current Leakage Flux & Ultrasonic Testing Equipment)
- M/s Socomate International, France (For Digital Ultrasonic Solutions)
- M/s Slicker Technology, Germany (For Rotary Ultrasonic Testing Systems)
- Electronic & Engineering Services Pvt Ltd. has a team of qualified, & experienced personnel specialized in the field of Mechanical, Electronic & Software Engineering, to extend aftersales services.





TPAC is the global leader in Ultrasonic Non-Destructive Testing, offering standard and tailored solutions to assess products and asset integrity in most industries. TPAC develops ultrasonic testing devices and software for inspection during manufacturing and in service maintenance, prioritizing compactness, high performance, versatility and modularity, especially for automatic inspection.

Our range of services is diverse and covers everything from Standard Electronics, Software solutions, OEM (Original Equipment Manufacturer) products, to customized solutions. We excel in various techniques, starting from Conventional UT, Phased Array and inline rackable customized solutions, with active development in the latest imaging technologies such as FMC/TFM, PWI, AWG and CTUT.

Over the past 25 years, the company has earned the trust of most prestigious customers in and beyond NDT actors in the industry as well as in the research.

- Ultrasound Non-Destructive Testing Conventional UT
- Phased Array

FMC/TFM

- Air-coupled UT
- Advanced Imaging Technologies

Application-focused Software

Looking for a unique solution in ultrasound and phased array testing? Contact us today: Sandeep Murjani - Country Manager India sandeep.murjani@tpac-ndt.com | +91 8879853405



energising lives

Fortune Global 500 Company, Bharat Petroleum is the second largest Indian Oil Marketing Company and one of the integrated energy companies in India, engaged in refining of crude oil and marketing of petroleum products, with presence in the upstream and downstream sectors of the oil and gas industry. The company attained the coveted Maharatna status, joining the club of companies having greater operational & financial autonomy.

Bharat Petroleum's Refineries at Mumbai, Kochi and Bina have a combined refining capacity of around 35.3 MMTPA. Its marketing infrastructure includes a network of installations, depots, fuel stations, aviation service stations and LPG distributors. Its distribution network comprises over 22,000+Fuel Stations, over 6,250 LPG distributorships, 525 Lubes distributorships,123 POL storage locations, 54 LPG Bottling Plants, 63 Aviation Service Stations, 5 Lube blending plants and 4 cross-country pipelines as on 31.08.2024.

Bharat Petroleum is integrating its strategy, investments, environmental and social ambitions to move towards a sustainable planet. The company has chalked out the plan to offer electric vehicle charging stations at around 7000 FuelStations over next 5 years.

With a focus on sustainable solutions, the company is developing an ecosystem and a road-map to become a Net Zero Energy Company by 2040, in Scope 1 and Scope 2 emissions. Bharat Petroleum has been partnering communities by supporting several initiatives connected primarily in the areas of education, water conservation, skill development, health, community development, capacity building and employee volunteering. With 'Energising Lives' as its core purpose, Bharat Petroleum's vision is to be an admired global energy company leveraging talent, innovation & technology.







"NESL's remarkable journey began as a groundbreaking joint venture between the NICCO Group and Furmanite International Limited, establishing itself as India's pioneer in On-line Leak Sealing and Safety Valve testing services. Today, the company stands as an independent powerhouse in specialty maintenance, offering services not just across India but globally.

As a distinguished member of the seven-decade-old NICCO Group, NESL has evolved into a technological leader in industrial maintenance. With an extensive network comprising 6 branches and 60 site offices nationwide, the company has built a robust reputation for excellence over three decades. Their comprehensive service portfolio includes innovative solutions like Online leak sealing, Safety Valve Testing, Belzona Composites and Coating Systems, Metal Stitching, Fleetfusion welding, and Onsite Machining.

NESL's expertise spans crucial industrial sectors, including thermal and nuclear power, petrochemicals, refineries, steel manufacturing, paper production, marine operations, oil and gas, and fertilizer plants. Their commitment to excellence is reflected in their mission to manufacture and deliver diverse, high-quality products and services using cutting-edge technology.

Looking ahead, NESL's vision centers on maintaining their position as the premier specialty maintenance service provider in the industrial sector. Their forward-thinking approach focuses on creating sustainable value for clients, employees, and stakeholders alike. This commitment to continuous improvement and excellence has established NESL as a trusted partner in industrial maintenance solutions across the continent."

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ZEISS in India is headquartered in Bengaluru and present in the fields of Industrial Quality Solutions, Research Microscopy Solutions, Medical Technology, Vision Care and Sports & Cine Optics.

ZEISS India has 3 production facilities, R&D center, Global IT services and about 40 Sales & Service offices in almost all Tier I and Tier II cities in India. With 1000+ employees and continued investments over 25 years in India, ZEISS' success story in India is continuing at a rapid pace.

#### **ZEISS Industrial Quality Solutions**

Your Partner for Multidimensional Industrial Metrology Our product range includes coordinate measuring machines, optical and multisensor systems as well as metrology software for the automotive, aircraft, mechanical engineering, plastics and medical technology industries. Innovative technologies such as 3D X-ray metrology for quality inspection and Industrial Microscopy for material analysis round off the product portfolio.

# **ZEISS Competence Centers India**

One stop solution for your measurement needs ZEISS Competence Center caters to the Industrial Metrology business group, equipped with the resources to provide service like training & development and ZEISS Academy Program for colleges. It also helps the division with on-site measurement service and subcontract measurement services in addition to sales support.





Transforming NDE and Radiation Safety Solutions

Headquartered in Mumbai, India, Choksi Imaging Limited, led by Mr. Samir K. Choksi, pioneers innovative Non-Destructive Testing (NDT) and Radiation Safety solutions.

# Our Expertise:

- Authorized All-India Distributor for OSERIX Gamma Radiography Equipment, Accessories, and Isotopes
- Authorized Pan-India Distributor for SPEC (USA) Industrial Radiography Equipment, Source and Maintenance
- Authorized Distributor for Teledyne ICM Portable X-Ray Generators
- Authorized Distributor for SILFLEX Radiation Shielding Materials (India and Middle East)

# Comprehensive Product Range:

- Industrial X-Ray Film & Chemicals (LASER)
- Industrial Radiography Device and Radiography Sources (Ir-192, Se-75, Co-60)
- Customized Shielding Solutions
- X-Ray Generators (Small & Large Focus)
- Real-Time Radiography-based Corrosion Inspection
- RADAC Lead Intensifying Screens and NDT-related Accessories

# Connect with Us:

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Website: www.choksi-asia.com

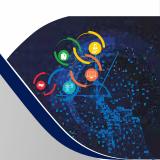


Proceg 70 Years of Legacy - founded 1954 in Switzerland, is the global leader in portable nondestructive testing of material properties of metal, concrete, rock, paper and composites. Inventor of Portable Leeb -The Equotip since 1975. Our Latest - The Equotip 550 is the most versatile all-in-one solution for portable hardness testing using Leeb, Portable Rockwell and UCI. Hardness measurements are made by using the dynamic rebound method Leeb, the static Portable Rockwell hardness and Ultrasonic Contact Impedance (UCI) method with a unique single probe UCI for HV1 to HV10. with wide Range of special Foot and Support Rings for Curved / complex Jobs. Equotip 550 takes advantage of a new generation full color, dual processor Touchscreen Unit with enhanced software capabilities. With the broadest conversion curve and material portfolio, you'll be ready for any testing scenario, ensuring accurate hardness measurements across a wide range of materials - Including High Alloy Steels P/T91, P/T92 Using Leeb and Using UCI for Aluminium, Titanium, Incoloy, SS 304L and More. Our Range includes Equotip 540LeebD or 540UCI for Limited applications upgradable to 550 – when a Need arise. Ultracompact Bambino and Piccolo no compromise in precision or accuracy. Equotip LIVE Products UCI and Leeb D – get closer to Industry 4.0 Compliance with data storage in cloud, GPS tag, Picture & comments in reports. We Strive to meet every need of Portable Hardness Testing solutions. SWISS made Quality with Accreditation ISO-IEC17025 with Worldwide Service Support.

https://www.screeningeagle.com/

India Partner – sales@sasthascientific.com, 9845016218







Magnafield Electronics and Engineering Private Limited, based in Navi Mumbai, is a staunch supporter of the "Make in India" initiative. Since our inception in 2013, we have been a leading supplier of NDT (Non-Destructive Testing) Products and Accessories, serving clients not only across India but also on a global scale. Our commitment to excellence is evident in our diverse product range, which includes UltraViolet Lamps, Radiographic Testing Equipment, Magnetic Particle Testing Equipment, Hardness Testing Equipment, Ultrasonic Testing Equipment, NDT Accessories, and Pre & Post Weld Heat Treatment Equipment. We are renowned for the superior quality and efficiency of our NDT instruments, featuring attributes like energy efficiency, high functionality, ease of operation, minimal maintenance, rugged construction, and extended service life. With customer convenience in mind, we offer prompt delivery, multiple payment options, and a quality-assured range. To ensure the highest quality standards, we maintain an in-house quality testing unit. Our directors, Mr. Parag Damudre (ASNT NDT LV-III in RT, MT, UT, PT) and Mr. Sarang Damudre (ASNT NDT LV-III in RT, MT, UT, PT), contribute their experience and innovative ideas, driving our remarkable success in this domain in a relatively short period.



- MODSONIC an ELECON group company is the Leading Indian manufacturer and exporter of Portable
  Ultrasonic Testing Equipment for more than 35 years. Our product range covers various models of
  Ultrasonic Flaw Detectors, Ultrasonic Thickness Gauges, Various standard and customized ultrasonic
  probes, Reference / Calibration Blocks and other allied accessories.
- Our manufacturing facility is fully equipped with all the facilities like Workshop, Advance Electronic Assembly line and Calibration units, Research and Development Cell, Application Laboratory, Training Centre etc. are all under one roof at GIDC naroda, Ahmedabad, INDIA.
- We have more than 3000 satisfied customers in India and Overseas, and are constantly committed in understanding the needs of our customers and continuously striving to maintain competitive edge by providing the best quality in our products.





At MR Chemie, We make the Invisible - Visible!

With a legacy spanning over 50 years, we formed our identity as a leading manufacturer of Non-Destructive Testing Chemicals and Equipments, partnering globally to make the world a safer place.

Headquartered in Unna, Germany, MR Chemie operates 2 production units (Germany and India) ensuring global availability across 65 + countries. Our relentless pursuit of excellence, coupled with customer centric innovation, positions us as leaders in the market. Central to our ethos is our commitment to sustainability and environmental stewardship.

At MR Chemie, we embrace new possibilities, constantly striving to deliver superior product solutions. We pioneer the development of safe chemicals for NDT applications, setting a new standard for industry-wide responsibility. Established in 1971, MR Chemie stands stalwart in the industry, renowned for its high caliber, reliable and precision chemicals and equipments. Specialising in an extensive array of solutions including Dye-Penetrant testing, Magnetic Particle testing, Leak detection, UV-Technology and our patented Crack Luminescence, we cater to diverse customer needs.

Our products, bearing the MR® mark, are trusted globally across various sectors, including Aerospace, Automotive, Defence, Marine, Oil and Gas, Nuclear, and General Industries. In partnership with 3AK Chemie, serving as our exclusive Manufacturer, R&D, and Distribution partner across the Asia-Pacific, Middle-East, and Africa regions, MR Chemie continues to push boundaries, ensuring safer, more efficient NDT practices worldwide."

Eastwest Engineering &

Eastwest Engineering & Electronics Pvt. Ltd. has been a leading manufacturer of NDT (Non-Destructive Testing) equipment and accessories for over 52 years. Throughout our journey, we have achieved numerous milestones, overcome challenges, and continuously sought new opportunities to innovate and serve our clients.

Our extensive product range is one of the broadest in the industry, encompassing equipment and accessories for Radiography, Magnetic Particle Testing, Ultrasonic Calibration Blocks, Vacuum Box Leak Detectors, and more. We also offer a comprehensive range of Pre- and Post-Weld Heat Treatment equipment. In addition to our product line, we provide tailored, innovative solutions to meet the unique requirements of our esteemed clients. Quality is at the heart of everything we do. A rigorous quality control system, managed by a highly qualified QC team, ensures that every product meets stringent international standards. We stand by our commitment to quality and reliability, supporting our products with excellent after-sales service.

Embracing modern advancements, we also offer a complete line of Digital Radiography systems, including X-ray machines, DR & CR systems, CT software, CT scanners, CR phantoms, manipulators, and cabinets.

As channel partners, we represent globally recognized manufacturers such as Cygnus (UK) for multi-echo ultrasonic thickness gauges, Comet (Switzerland) and ICM (Belgium) for portable and stationary X-ray machines, Dandong (China) for X-ray machines, and Mitech (China) for ultrasonic thickness gauges and hardness testers, among others. Eastwest Engineering is ISO 9001:2015 and CE certified, underscoring our commitment to quality and compliance with global standards.

34<sup>th</sup>
NON DESTRUCTIVE
EVALUATION & ENABLING
TECHNOLOGIES





Planys Technologies, founded in 2015 by IIT Madras alumni and faculty, is at the forefront of advanced underwater inspection solutions. Leveraging cutting-edge marine robotics, patented NDT sensors, and an Al-enabled analytics dashboard, Planys delivers unparalleled inspection accuracy, safety, and efficiency across sectors like oil & gas, petrochemical, power, steel, fertilisers and desalination. The Planys Analytics Dashboard (PAD) further enhances operational efficiency, reducing report analysis time by 99% and empowering data-driven decision-making.

With deployments across 400+ assets, including 70+ storage tanks and 50+ terminals/jetties, Planys has become a trusted partner to industry leaders such as Reliance Industries, Exxon, Shell, IOCL, BPCL, and HPCL. Its solutions eliminate risks to human divers, conduct online inspections without shutdowns, and provide comprehensive insights to ensure optimal asset performance. Planys' innovations include corrosion mapping without marine growth removal and advanced underwater concrete NDT. These technologies cater to critical assets such as pipelines, reservoirs, sumps, basins and marine terminals, offering cost-effective, environmentally conscious solutions.

Expanding globally to Saudi Arabia, the Netherlands, and Singapore, Planys is transforming asset inspection worldwide. Its newly launched Digital Twin Solution for integrating agnostic NDT data takes asset management to the next level, combining 3D visualization with realtime data for seamless interaction and intuitive insights. Planys Technologies is not just redefining underwater inspection but also revolutionizing industrial asset management, creating a safer, smarter, and more sustainable future for critical industries.

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Electro Magfield Controls & Services A Pioneer in Magnetic Crack Testing Machine & Systems was founded in 1995 in Chennai Tamil Nadu India known as the Detroit of India has established itself as a leading manufacturer and supplier of advanced Magnetic Crack Detector Systems Demagnetizers Penetrant Systems and a wide range of associated accessories. The company became the first Indian manufacturer to produce 3 Phase Full Wave DC equipment in India which marked a significant milestone in the nondestructive testing NDT industry in India. We are proud to have its products approved by leading international standards, including NADCAP, ASTM, and several others. These certifications highlight the company's ability to meet global quality benchmarks, ensuring that its products are trusted by industries worldwide. The company's impressive client list includes some of the most renowned original equipment manufacturers OEMs globally. Hindustan Aeronautics limited who makes parts for these customers Rolls Royce Pratt & Whitney Airbus Hyundai, Honda, Yamaha, Ashok Leyland, Tata Motors, Renault Nissan, Bharat Forge, TVS Group, and many others are among the esteemed companies. The company's equipment is widely used in various industries such as aerospace, automotive, defense, and heavy manufacturing. With over 2500 systems sold worldwide, primarily in India, We have cemented its position as a key player in the global NDT market. Our company is an authorized distributor for Chemetall a global leader in surface treatment and metalworking technologies and offers calibration and repair services for Spectro UV USA a specialist in ultraviolet UV light systems for NDT applications.





VisiConsult is a family-owned company located in Northern Germany and the leading specialist for customized X-ray inspection systems. To ensure premium quality all our products are developed and produced locally in Germany as turnkey solutions. This leads to cutting-edge technology and high flexibility. Being active in several fields like Non-Destructive Testing (NDT), public security, and the electronics manufacturing industries VisiConsult offers a sophisticated product portfolio.

VCxray is a business unit of VisiConsult, a global market leader in the field of customized and standard X-ray inspection systems.

Our business unit serves a broad variety of markets from automotive to aerospace supplying cutting-edge X-ray inspection systems for non-destructive testing (NDT), quality assurance and process improvement.

To ensure a premium quality, all products are developed and produced at local manufacturing hubs as turnkey solutions according to international standards and ISO 9001. This results in highest performance and an unmatched flexibility.

Our goal is to provide inspection solutions via tailored systems, while guaranteeing a premium customer service. More than 25 years of expertise in image processing and X-ray technology, combined with experienced engineers, result in solutions that regularly set new industry standards.



# IRC ENGINEERING SERVICES INDIA PVT. LTD.

IRC Engineering Services (India) is One Stop Solution provider of mostly all your Testing, Inspection & Certification requirements with more than 30 Years of Industry Experience, 200+ Employees & 300 locations services provided worldwide. We at IRC offer Services in Oil & Gas, Refineries, Power Sector, Petrochemicals, Fertilizers, Cement Industry, Pulp & Paper, Sugar Mills many more industries.

# Certification & Accreditation;

SO 9001:2015, ISO 14001: 2015, ISO/IEC 17025: 2017 & ISO/IEC 17020:2012 Certified

# Company.

- Approved for Boiler RLA as per IBR -1950 by CBB.
- National Accreditation Board for Testing and Calibration Laboratories approved Material

# Testing Laboratory.

PESO approved the Competent Person as per SMPV (v) Rules.

### Please find below the Services Offered by IRC;

- Long Range Ultrasonic Testing
- Pulsed Eddy Current Testing
- Short-Range Ultrasonic Testing
- Pipeline Scanning using Magnetic Flux Leakage
- Automated Ultrasonic Testing Corrosion Mapping
- Alternative Current Field Measurement
- Tube Inspection
- Phased Array UT & Time of Flight Diffraction



- Tank Floor Scanning by Magnetic Flux Leakage
- Helium Leak Detection Test
- In situ metallography (Replica test)
- Boiler Tube Corrosion Mapping by RFET
- Boiler Tube Scanning by ULTRA-Bot (Thickness Mapping Rover)
- Advanced Electromagnetic Technique in Boiler Tubes (AET)
- Destructive Testing
- 3D Scanning
- Fitness For Services
- Failure Analysis
- · Residual Life Assessment of Boiler, Steam Turbine
- Third-Party Inspection
- Boiler Water Chemistry Audit

Steam path Audit of Steam Turbine Chemical Cleaning of Boiler, Heat Exchanger and Pipeline Rope Access



Keeping the vision of "Make in India", M/s. Arora Technologies (P) Limited is focusing on Manufacturing and Distribution of NDT Products & Accessories. Our vision is to Innovate, design and manufacture NDT Products, Systems and Accessories for global markets by incorporating Quality & Excellence in our DNA. We are committed to build long-term relationships with our customers and pursue our business through innovation, latest technology & unrelenting quest for excellence.

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TECHNOFOUR is the pioneer and leader in the field of Eddy Current Testing in India. Technofour have been manufacturing a wide range of instruments and system based on Eddy Current technique since 1972 and command more than 70% market share in India. Technofour have also exported several systems to Middle East, China & Latin America. Range of Eddy Current products include portable instruments like Conductivity Meter, System for Metal Segregation of various automobile components on the basis of metallurgical variation and Flaw Detection Systems for Tubes, Bars and Wires.

The latest additions to its portfolio are the Magnetic Leakage Flux systems, facilitating Transverse and Longitudinal defect detection, Automated Ultrasonic Test systems for Bars/Seamless & welded tubes/pipes and the compact EddyUSB and UTUSB, credit-cardsized Eddy Current and Ultrasonic Testers, respectively. Visit https://www.technofour.com

# **Contact Details:**

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Blue Star Engineering & Electronics Limited has built a strong reputation for providing advanced technology products and turnkey engineering solutions across multiple industries in India. Our Non-Destructive Testing (NDT) line of business is a leading provider of NDT instruments and equipment, supporting Indian industries since 1980 with high-quality, highperformance testing equipment and customized automated solutions. We offer semi/fully automated systems for various industrial inspection needs, utilizing technologies such as Ultrasonic Testing, PAUT, Industrial Radiography, Eddy Current Testing, Computed Radiography, Magnetic Particle Inspection, and Metrology.



# **Our Expertise**

Founded in 1958, Sonatest is the leading manufacturer of Ultrasonic inspection equipment. We are recognised and respected around the world for the quality of our rugged portable products which can be found in every industry and application.

Pioneering Ultrasonics in the NDT Industry Since 1958

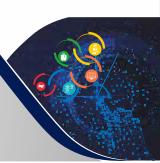
Whether it is conventional ultrasonics or advanced cutting edge phased array with TFM. Sonatest is your partner for Non-Destructive Testing solutions whatever your industry or application.

Our products are used by the worlds biggest and most innovative companies. Shell, Airbus, Siemens and Arcellor Mittal are amongst the thousands of customers who use Sonatest instruments to ensure that their products and processes are safe and reliable. Innovative Product Design

Sonatest products are guided by the values of Simplicity, Capability and Reliability. Innovation is at the core of not only our design and development programmes but our whole way of working. We strive to provide an easy enjoyable experience when working with and being a part of the Sonatest family.

The market leading flaw detector WAVE has gained a reputation which is the envy of our competitors. Our user interface has set the industry standard. The advanced phased array Veo3 reinforce our reputation for innovative product development of instruments focussed on providing the technician with an efficient user experience. The RSflite leads the world in composite inspection technology.

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Since 1983, Arudra has been at the forefront of offering turnkey engineering products & services to process industries, particularly across Power, Oil & Gas, Petrochemicals and Iron & Steel. Arudra continues to stand as one of the leading Chemical Cleaning & NDT/Inspection service providers in India, having executed projects across 200 public & private sector thermal power plants. We have evolved over the years by integrating our offerings into a range of performance improvement products & services that help our industry clients solve a range of maintenance issues and save enormous costs over the course of operation. Arudra believes in offering the best-in-class products & services at all times and have over the years strived to adapt international best practices by liaising with expert engineering counterparts across USA & Switzerland.

Arudra enjoys the privilege of being a preferred supplier to many of the private steel plants in India for Design, Engineering, Manufacture and Supply of Bulk Material Handling Systems-Pulleys and Idlers. Arudra's values revolve around safety and quality and our well experienced engineers abide by international environment & safety standards with no compromise on quality of products & services provided. Emphasis on quality and a global outlook have helped Arudra secure large engineering contracts at a global level and we take pride in serving process industries across 27 countries in a range of turnkey engineering activities.



Teledyne FLIR designs, develops, manufactures, markets, and distributes technologies that enhance perception and awareness. We bring innovative sensing solutions into daily life through our thermal imaging, visible-light imaging, video analytics, measurement and diagnostic, and advanced threat detection systems.

FLIR cameras with Lock-In, Transient, and Pulse capability can perform advanced inspections such as Non-Destructive Testing (NDT) or stress mapping, resolving temperature differences as low as 1 mK. NDT is widely used to evaluate the properties of a material, component, or system without causing damage. IR cameras can detect internal defects through target excitation and the observation of thermal differences on a target's surface. Thermal imaging is a valuable tool for detecting defects and points of failure in composites, solar cells, bridges, and electronics. It is also a great tool for thermal mapping of stress when performing materials testing





SVK Electronics is a leading manufacturer and supplier of NDT & PWHT products. SVK Electronics is a well-established company with a strong reputation for quality and customer service.

We offer a wide range of products, including:

- 1. Radiography accessories
- 2. Digital Radiography Systems
- 3. Pre Heat & PWHT equipments & accessories
- 4. Conventional Ultrasonic Flaw Detectors & thickness gauges
- 5. PAUT Systems along with probes and wedges
- 6. UT scanners for weld inspection and corrosion mapping
- 7. MPI equipment up to 10,000 Amps
- 8. Videoscopes
- 9. Customized solutions to NDT needs

We are a team of highly skilled and experienced engineers who are experts in the field of NDT and PWHT. We use the latest technology and techniques to design and manufacture their products. SVK Electronics is also committed to providing excellent customer service. We have a team of dedicated customer service representatives who are available to answer any questions or concerns that you may have.

SVK Electronics is committed to providing high-quality products to their customers. We are also committed to providing customized solutions to meet the specific needs of their customers.

Head Office: Gala No. 1, Jalaram Indi Estate, Ketkipada Road, Dahisar (East) Mumbai -400068.

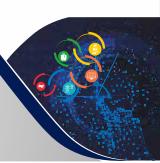
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Mob: +91 9320281471 Email: info@svkelectronics.net Web: www.svkelectronics.net



TCR Advanced aims to be the best at all that they do -- the goal is to make a positive difference, help clients overcome their challenges, and maximize their success. TCR Advanced has successfully conducted over 6000 investigations and has served over 1700 clients nationally and globally. TCR enables companies across the globe to efficiently manage plant operations and optimize asset integrity. TCR continuously provides innovative solutions that help its clients create an advantage from every opportunity.







Detect Technologies is redefining industrial intelligence through cutting-edge Industrial AI solutions. Born from innovation at IIT Madras in 2016, we have rapidly established ourselves as a trusted innovator in industrial automation and monitoring solutions, with an active presence across 28 regions worldwide.

Our integrated ecosystem combines advanced computer vision, cloud computing, robotics, and IIoT sensors to drive unprecedented operational excellence.

At the heart of our innovation lies T-Pulse™, our advanced data driven AI platform powered by 250+ sophisticated detection models. This flagship solution analyses the data form IoT sensors, Mobile devices, and existing databases to deliver actionable insights for driving last mile changes.

We serve diverse industries including upstream and midstream operations, downstream processes, logistics, fabrication, construction, and manufacturing. Our solutions comprehensively address workplace safety, inspections, operations, and security needs, trusted by industry leaders like Shell, ExxonMobil, Tata Steel, and the Adani Group. Our vision extends beyond providing solutions as we pioneer industrial transformation through Al-driven innovation. By transforming operational challenges into strategic advantages, we empower businesses to protect assets, optimize operations, and achieve sustainable growth in an increasingly complex industrial landscape.

Through continuous innovation and unwavering commitment to excellence, Detect Technologies continues to set new standards in industrial automation, making operations safer, more efficient, and more reliable.

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#### SUSTAINABLE SOLUTIONS IN ENERGY & ENVIRONMENT

Thermax is one-stop utility partner to both industrial and commercial segments, helping customers achieve better resource productivity and bottom lines while maintaining a better environment.

Thermax Babcock & Wilcox Energy Solutions (TBWES), a wholly-owned subsidiary of Thermax Limited provides equipment and complete solutions for generating steam for process and power needs through combustion of various solid, liquid, and gaseous fuels, as well as through heat recovery from turbine/engine exhaust and (waste) heat recovery from industrial processes. TBWES has extensive experience in indigenising technologies and handling complex waste materials such as Municipal Solid Waste, Refuse Derived Fuel, Agro-Waste and Industrial Non-Recyclable Solid Wastes in an environmentally friendly way.





MISTRAS PHYSICAL ACOUSTICS GROUP ESTABLISHED IN 1978. WE ARE LEADING MANUFACTURERS OF STATE-OF-THE-ART ACOUSTIC EMISSION SYSTEMS, SOFTWARE, SENSORS AND ACCESSORIES. WE ARE A GLOBAL COMPANY WITH LOCAL REACH. WE ARE VERY WELL SPREAD ACROSS THE GLOBE AND HAVE PRESENCE IN ALL THE DEVELOPED COUNTRIES. WE ARE LISTED AT NYSE AND WE CARRY ALL THE REQUIRED ISO CERTIFICATIONS FOR DESIGN, MANUFACTURE, REPAIR AND CALIBRATION OF AE EQUIPMENT AND SENSORS.

GROUP IS HAVING APPLICATION EXPERIENCE OF MORE THAN 45 YEARS. WE NOT ONLY SELL OUR EQUIPMENT, WE TRAIN OUR CUSTOMERS IN THEIR SPECIFIC APPLICATIONS BY PROVIDING END TO END SOLUTIONS. WE HAVE SOLD MORE THAN 200 AE SYSTEMS IN INDIA IN PAST 20 YEARS. EXPECT EXCELLENT SERVICE AND TECHNICAL SUPPORT FROM US.

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The Viswa Group is a purpose driven organization with a passion to help the customers in the Marine and Petrochemical Industries. Viswa's method of working is from inside out. It starts with the question, "Why are we doing this?" and further goes on to "What are we doing?" and then to "How are we doing it?" The dimension of Why is unique to Viswa.

This passion to serve the industry has led Viswa into areas of detailed analysis of the fuels and identifying contaminants and adulterants in the fuel using statistical methods data analysis to pin point problem areas globally. Viswa has developed algorithms and benchmarks to make a complex industry much simpler to understand.

With 8 Labs located Globally, the highly experienced and trained staff at the various Viswa locations works with a single focused objective of customer satisfaction in the areas of Fuels, Lubes, Surveys and Water Testing.

Well-versed in the complex regulatory landscape governing marine fuels, Viswa helps ship owners and operators comply with international standards set by the International Maritime Organization (IMO), ensuring environmental responsibility and safety at sea. Viswa assist ship operators in implementing proactive maintenance strategies to preserve and extend the lifespan of their equipment and reduce operational risks. Viswa is strongly committed to providing solutions to the problems our customers face and to empower our customers by sharing our knowledge, our research, and our problem-solving abilities.

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Over 50 years of experience in the field of Non-Destructive Testing having operations in India, GCC, Africa and expanding worldwide.

The hard work, sincerity and dedication put together have brought us to its present standing with the inclusion of all the NDT test methods under our wing. This includes test methods like Radiography (Conventional and Advanced), Ultrasonic (Manual and Automated), Magnetic particle, Liquid Penetrant, Eddy Current Etc.

There is not a single project of typical nature in India for which IXAR has not worked and thus vast experience gained,

is the base of its full confidence to undertake any challenging job irrespective to size and technical complexities.

Ixar strives for excellence in the concept of quality, soon realized the fruit of popularity and is certified with ISO 9001:2018, IXAR strives ahead to acquire latest technology to cope with the present day challenges in the field of NDT. Today, IXAR is established leader in the field of Non-Destructive Testing methods all over India and in some part of the world. As on date company has ddedicate staff strength of more than 1000 employees under its various wings.

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HPCL-Mittal Energy Limited (HMEL) is a unique Public Private partnership set up in 2007. It is an equal Joint Venture of Hindustan Petroleum Corporation Limited (HPCL) and Mittal Energy Investment Pte Ltd, Singapore, each holding a stake of about 49% with the balance being held by Indian Financial Institutions. HMEL is the largest company in the state of Punjab in terms of capital investment.

HMEL is a Board run company which at present operates an 11.3 MMTPA refinery and associated facilities at Bathinda. It also operates a 1017 km long crude pipeline from Gujarat to Punjab and a crude oil terminal at Mundra, Gujarat along with a Single Point Mooring System (SPM) for import of the crude oil feedstock. HMEL's Refinery is an energy-efficient, environment-friendly, high distillate yielding complex designed to produce high-value-added petroleum products. It holds the unique distinction of being a 'Zero Bottoms Refinery' with various measures in place to minimize gaseous, liquid or solid waste. It has one of the highest Nelson Complexity Indices in the region and is designed to process a wide variety of crude oil including heavy, sour and other opportunity crudes. The Refinery produces Bharat Stage-VI compliant transportation fuels viz, Motor Spirit & High Speed Diesel apart from other liquid products such as Superior Kerosene Oil, Aviation Turbine Fuel, LPG, Naphtha, Mineral Turpentine Oil & Hexane. The solid product portfolio comprises of the polymer Polypropylene as well as the by-products Petcoke, Bitumen & Sulphur.



HMEL is responding to reduce the country's dependence on imports and meet the ever-growing local demand for Polypropylene (PP) and Polyethylene (PE) and has undertaken a massive over US\$ 3 Billion expansion in petrochemicals at Bathinda. The new complex features a world-class Dual Feed Cracker Unit of 1.2 Million MT/annum of Polyethylene (PE) and 0.5 Million MT/annum of Polypropylene (PP) capacity to cater to all major application segments.

HMEL is committed towards high standards of safety, health and sustainability with a strong focus on preserving the environment. HMEL has received a Five Star Rating and the Sword of Honour from British Safety Council for excellence in the management of health and safety risks at work.

www.hmel.in

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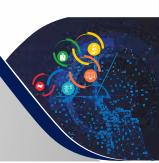


refinery with over five decades of dominance in South India. Equipped with world-class refining technologies and a Nelson Complexity Index of 10.03, CPCL processes 10.5 MMTPA of crude, producing BS VI fuels, lubes, wax, and petrochemical feedstocks. It is the only refinery in India with combined lube and wax manufacturing facilities and a supplier of ISROSENE fuel for ISRO and JP-7 equivalent fuel for defense, contributing to Aatmanirbhar Bharat.

CPCL leads in sustainability, pioneering India's first Windmill farm (17.6 MW) in Tamil Nadu and setting up a Sewage Reclamation Plant processing 5 MGD of Chennai city's wastewater. Its 5.8 MGD Sea Water Desalination Plant, operational since 2009, was a first in the industry. CPCL supports MSMEs with specialty products like paraffin wax, benefiting over 30,000 livelihoods. The upcoming 9.0 MMTPA Cauvery Basin Refinery and Petrochemicals Limited (CBRPL) at Nagapattinam, in partnership with IOCL, will adopt indigenous technologies, create 13 million man-days of employment, and drive regional economic growth.

Committed to Net Zero by 2046, CPCL integrates environmental conservation projects and renewable energy initiatives. As a leading energy company, CPCL contributes significantly to India's socio-economic development, addressing the energy needs of Tamil Nadu and beyond.







Dhvani Research & Development Solution Pvt Ltd is a spin-off from the Centre for Nondestructive Evaluation at IIT Madras formed in the year 2008 with the objective of transferring academic research into reliable solutions for industrial requirements. With over 14 years of operational expertise, having delivered more than 70 NDT systems successfully. Dhvani research is an approved vendor with leading aerospace industries, automotive industry, energy industry and manufacturing industry and has supported them in,

- Inspection of CFRP and GFRP composite structures.
- Inspection of aluminium and composite sandwiched honeycombed structures.
- Inspection of Al, Ti, steel forged components.
- Automotive bearing inspection.
- Transmission components friction welding inspection.
- X-ray inspection of Aluminium, steel castings.
- Inspection of switch gears.
- Inspection of brazing.
- Inspection of bus bars solder quality.
- Inspection system for large forging structures weighing upto 10 tones.
- Inspection system for the cleanliness evaluation of steel.
- Inspection system for the evaluation of castings according to various standards like ASME, AMS etc.
- HIC Ultrasonic immersion system as per NACE Standard.
- Ultrasonic Immersion system for SEP 1927 standard.

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Incubated at IIT Madras Research Park, we, at Dhvani Analytic Intelligence (DAI), empower industrial insights from NDE using intelligence. We have physics-based data-driven AI solutions for providing insights in non-destructive evaluation (NDE) and inspection workflows.

DAI, which is a part of Dhvani Group, has delivered machine learning solutions for video analytics, image defect analysis and standard operating protocol applications for quality control and compliance. DAI has produced automated defect recognition (ADR) and measurement solutions in multiple NDT domains including vision, ultrasonic, radiography, radio frequency, liquid penetrant inspection, magnetic particle inspection to assess industrial and structural components such as welds, aluminium castings, and shipbuilding structures.





XYMA Analytics, founded in 2019, is a pioneering company that developed ultrasonic waveguides, a novel technology addressing critical problems in industries including Oil & Gas refineries, Aluminium Smelters, Steel Plants, Semiconductor, Lubrication Oil, Paints, and the Marine sector. Unlike existing technologies, XYMA's sensors perform multi-point and multi-parameter measurements, increasing measurement density. These sensors withstand high temperatures up to 1450°C and can be configured into any shape to retrofit existing assets with minimal invasion.

The companyâ ™s vision is to create reliable sensors for high-temperature industries and democratize sensor-based process efficiency by providing rich data sets to customers. With a team of expert engineers and researchers from IIT-Madras, XYMA Analytics develops novel sensor products, installs them at customer sites, maintains them, and provides data analytics for lifecycle management to influence operational efficiencies. The company has received the National Technology Award, participated in the Shell E4 program, was a finalist in the Qualcomm Design in India Challenge in 2021, and has been recognized as the most promising startup by the Government of Tamil Nadu and Vedanta Group.



The Center for Nondestructive Evaluation (CNDE) was established at the Indian Institute of Technology, Madras, in April 2001. It is Asia's leading academic center for research and technology translation in Nondestructive Evaluation (NDE). CNDE's mission is to develop deep-research-based nondestructive technologies aimed at improving performance, enhancing safety, and extending the lifespan of industrial applications for the benefit of society. The vision is to become the world's largest center for deep research and technology translation in the field of NDE. CNDE specializes in non-destructive imaging and evaluation, structural health monitoring (SHM), and online process parameter measurements in harsh environments. It utilizes both acoustic and electromagnetic spectrum technologies for industrial applications. CNDE is currently focusing on five research themes. Ubiquitous Sensing, Structured Materials for Imaging, Edge Intelligence & Soft Sensing, Pervasive Inspection & Global Inspection. CNDE's deep-tech and translated research work with IIT's innovation ecosystem resulted in 100 + Intellectual property and 13 start-ups in the NDE domain, employing over 1,200 people. CNDE is establishing the NDE Consortium (NDEC) to tackle real-world challenges in Non-Destructive Evaluation (NDE) and Structural Health Monitoring (SHM) through collaborative research and the development of world-class resources for NDE.







We are the Authorized System Integrators for M/s. Siemens Healthineers GmbH for their SILAC Series Accelerators up to 9 MeV for NDT applications in India. The SILAC is compact and modular gives flexibility for the users. With 1000 Hz PRF, you can do X Ray Scanning than Imaging

#### Authorized Distributors in India for:

- 1. RITEC USA High Power and High Energy Ultrasonic Pulser Receiver Systems up to 20 KW RMS and 1800 Vp-p
- 2. Xarion GmbH Optical Microphone to measure Air borne Ultrasound to detect defects
- 3. OPTECH Ventures USA Laser UT System Standard and High temp up to 1300 deg C
- 4. OPTRION, Belgium Advanced Laser Shearography System.
- 5. Excillum Sweden Metal jet with Liquid Anode system 160 kV with 1 KW power and Nanotube X Ray System with 150 nm resolution for R&D applications.
- 6. Grindosonic BVBA, Belgium Direct measurement of E & G Modulus of almost all materials.
- 7. We also undertake Customised Automation based on applications.

Contact Person: Mr. D. Simon Amallraja Mobile: 98480 43309 / 98663 43309

TeleFax: 040 - 2711 0445

E Mail: amallraja.simon@anutechconsultant.com

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Eddyfi Technologies provides the most advanced NDT technologies in the world, helpingOEMs, asset owners and service companies enhance productivity, save lives, and protectthe environment. Its mission is to provide unmatched advanced NDT solutions enabled by itsexpertise and technology leadership. Eddyfi Technologies offers a diversified portfolio ofNDT sensors, instruments, software and robotic solutions for the inspection of criticalcomponents and assets in key industries such as rail, aerospace, energy, and powergeneration.





ANSA TRAINING & QUALITY ASSURANCE PRIVATE LTD, founded in October 2017 in Chennai, is dedicated to providing ISO 9712 NDT Certification Training with the highest standards of quality and integrity.

Based in Chennai, India, ANSA offers internationally recognized NDT Training and Certification and serves as an Authorized Training and Examination Centre. Our facility is certified to ISO 9001:2015.

ANSA TIC VERITAS (SINGAPORE) PTE LTD, previously known as ANSA WENS Quality Assurance (Singapore) PTE Ltd, is an Authorized Qualifying Body. The certification body is Non-Destructive Testing Society of Singapore (NDTSS), which is accredited by SAC Singapore under the Personnel Certification standard ISO/IEC 17024:2012. The certificate is issued by NDTSS, Singapore. The certification Body NDTSS is part of ICNDT (International Committee of Non-Destructive Testing) MRA Schedule 2, hence the certificate is recognized and accepted globally.

ANSA Chennai offers a full range of NDT Training and Certification courses to support industries locally and globally. These courses cover a variety of product sectors (such as Welds, Casting, Forging, Tubes, and Pipes) and industry sectors, including Pre-Service and In-Service Manufacturing, for Levels 1, 2, and 3. Available certification methods include:

- 1. Radiography Testing
- 2. Ultrasonic Testing
- 3. Magnetic Particle Testing
- 4. Penetrant Testing
- 5. Visual Testing
- 6. Phased Array Ultrasonic Testing
- 7. Time of Flight Diffraction
- 8. Eddy Current Testing

ANSA Chennai is also authorized to conduct training in compliance with the ISNT scheme IS 13805 and the ICN (ISO 9712) standards, further underscoring its commitment to quality and global recognition.

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Pulsecho Systems est. in 1976 is an SSI Unit making highly reliable instruments for maintenance and upkeep of industrial units and plants. Our main products are for preventive and predictive maintenance and quality assurance.

Our two brands, Pulsecho Systems and Optel, have developed more than 30 different portable products for field use with highest reliability and quality. We enjoy a wide customer acceptance and reputation. The shear population of some of these instruments have made them an industry standard. We have earned laurels and awards of many a forum like Indian Society for Non Destructive Testing (ISNT), Chamber of Commerce and Industry, NATIONAL ASSOCIATION FOR APPLICATION OF RADIOISOTOPES AND RADIATION IN INDUSTRY (NAARRRI) etc.

Our products are in use in more than 10 countries. By focusing on an excellent after sales service we enjoy the customer's trust, loyalty and respect.



IRICO group stand apart with the distinction of being one of the few Companies in India to use sophisticated techniques in NDT. Applying its art of perfecting High-Technology using the latest Equipment's. IRICO group has kept India on the front line of International Technology having foreseen further inflow of Advanced Technology into India. IRICO group has brought itself ahead of time by adopting State of the ART - NON-DESTRUCTIVE TECHNIQUES.

IRICO group has highly qualified and dynamic NDE Engineers with vast experience in the field of NDT. To back up their efforts, with a team of dedicated professional and trained Engineers to the requirements of Atomic Energy Regulatory Board - AERB / Bhabha Atomic Research Center - BARC, American Society for Non-Destructive Testing - ASNT (SNT-TC-1A), Indian Society for Non-Destructive Testing – ISNT (IS 13805), British Institute of Non-Destructive Testing – BINDT (PCN), European Standard – BS EN ISO 9712 and European Pressure Equipment Directive - PED 2014/68/EU.

"IRICO group takes pride of being the first and only Company in India, to have all its laboratories accredited by NABL for permanent and on-site facilities, to offer all disciplines of NDT as per the national & international standards."

Activity profile covers FOUNDRIES, VALVE MANUFACTURES, AEROSPACE, DEFENCE, CROSS COUNTRY PIPELINES, REFINERIES, THERMAL POWER STATIONS, HYDRO-ELECTRIC POWER STATION, NUCLEAR POWER PLANT, SHIP INSPECTION, INSTRUMENTATION, PRESSURE VESSELS, STORAGE TANKS, MOUNDED BULLETS, SHUT DOWN / ANNUAL MAINTENANCE, PLANT PIPING, HORTON SPHERES & AUTOMOBILE INDUSTRIES.





M/s. JSC IT Concepts India Pvt Ltd, New Delhi is a 100% subsidiary of A/O Intech, Russia, (Group Company of IT Concepts having presence in USA, Germany, Singapore, and Russia), who is world leader in manufacturing Industrial Endoscope used in various industries for quality inspection purpose and as a NDT tool. Recently Intech, Russia has started manufacturing Industrial Endoscope through its 100% subsidiary in India, under make in India category promoted by Govt. of India. Industrial Endoscopy is at home in diverse fields of applications. wherever local conditions (Inaccessibility) or environmental conditions (Temperature, Contamination, etc.) prevent direct visual observation, monitoring of technical installations and production processes, Industrial Endoscopy fulfils the resulting need.

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Scaanray Metallurgical Services incorporated in the year 1983, offering various NDT services like Ultrasonic, Magnetic Particle, Penetrant, Radiography (X Ray and Gamma Ray), PMI, Hardness Testing have now ventured into Advanced NDT Services like Phased Array UT, Digital Radiography using Computed Radiography, Flat Panel Radiography, Film Digitisation Services using Industrial Film Digitiser, Heat treatment by Temporary Furnace, Internal Oil firing and localised SR. We have been catering these services to various sectors like Petro-Chemical, Refinery, Power plant (Thermal, Nuclear, Hydro-electric), Steel plant, Cement plants etc.







Topax NDT Solutions provides worldclass, reliable, consistent, cost-effective and built to perfection advanced NDT Inspection Solutions to a wide spectrum of industry verticals like Oil & Gas, Power, Defense, Chemicals & Fertilizers, Automotive, Aviation, Aerospace, Armed forces and Heavy Engineering Sectors including NDT Service Provider.

We provide complete end to end solutions from conventional to Advance NDT in RT,UT,ET.

- 1. Array Corporation: Array's 2905 Laser Film Digitizer meeting EN-14096-2, ASTM E-1936, ASMEsec-V-2&DS9grade. Provides High Quality images uitable for storage & archival.
- 2. Film Digitization Services with Array 2905 (DS9 grade).
- 3. Duplex IQI & Phantom require for CR / DR applications.
- 4.: provides World Class X-ray Films, Automatic Film Processor, Chemicals, Imaging Plate, Computed Radiography(CR) & Flat panel Detector [(DR) Non-glass 98/139/145microns & Glass 75/100microns] with Industrex User Friendly Software, Server Solutions.
- Zetec- (an Eddyfi Company) provides Phased Array Ultrasonic testing with unique Paint brush / Corrosion Monitor Solutions. Topaz-32 / 64, Weld Crawler. MIZ-21C (Hand held Recordable, ECT solution replacing conventional MT & PT with SAprobe)& MIZ 200 for Tube inspection & various types of Probes

# Solutions Built to Perfection

- 6. Repair Services-Automatic film processor, Array2905 film digitizer, Digital Radiography System.
- 7. Phase Array / TOFD Probes & Wedges.

#### Contact us:

Address:B61/114,VeenaIndestate,Opp.Monginis Cake factory, off New Andheri Link Road, Andheri (West), Mumbai 400053 Tel Offic:+918356853922.

E-mail: reply@topaxndtsolutions.com | Website: www.topaxndtsolutions.com





Comet X-ray provides industrial X-ray modules designed to be effectively integrated for maximum customization. Our metal-ceramic X-ray tubes are unmatched for industrial applications and can be fully optimized for your image chain. By choosing only the elements you need, you can reduce the cost of unnecessary built-in accessories.

We are your one-stop-shop, supplying all the integrated components for your X-ray module to reduce work for your supply chain. All X-ray modules are functionally tested as a system before delivery to reduce integration and testing time. The test report is your guarantee. A user-friendly interface gives you easy access to protocols to provide smoother workflows from installation to operation. Combine this with easy access and control of key generator parameters for a swifter and more cost-efficient installation process.



Welcome to VIBRANT's showcase at this year's NDE 2024! We are proud to participate in this esteemed gathering of industry leaders, innovators, and professionals who share a commitment to excellence in the field of Nondestructive Testing (NDT). For over 15 years, Vibrant NDT Services has been at the forefront of NDT technology, delivering advanced solutions that ensure safety, quality, and efficiency across various sectors, including aerospace, Automobiles, energy, oil& gas, infrastructure, and manufacturing.

#### Services

- Ultrasonic Testing
- Magnetic Particle Testing (MPT)
- Liquid Penetrant Testing (LPT)
- Tubes Inspection: ECT, RFET, IRIS, MFL.
- Helium Leak Testing
- Phased Array Ultrasonic Testing (PAUT)
- Long Range Ultrasonic Testing (LRUT)
- Acoustic Pulse Reflectometry Inspection System (APRIS) Products
- Magnetic Particle Inspection Equipment (Prod Type, Bench Type)
- Eddy Current testing (Manual, Semi-Automatic, fully automatic system)
- Fluorescent Penetrant Testing system
- Ultrasonic bar, tube, plate Inspection system
- All type of NDT calibration blocks
- Eddy Current/RFET Probes for tube inspection.
- Scanners, Encoders for PAUT

In a rapidly evolving industry, Vibrant NDT Servcies prioritizes research and development to introduce new methodologies and tools that enhance testing accuracy and efficiency. Our collaborations with global experts and institutions keep us ahead in understanding emerging trends and adapting swiftly to the needs of modern engineering.

Thank You for Visiting Us We are excited to share insights, discuss projects, and explore how we can collaborate to contribute to safer, more efficient operations in your industry. visit www.vndndt.com or contact us at info@vnsndt.com/+919444376041.







Peak NDT Limited is a leading specialist in designing, manufacturing, and supporting high performance ultrasonic instrumentation and solutions. With over 35 years of experience, our cutting-edge MicroPulse technology has been at the forefront of ultrasonic Non-Destructive Testing (NDT) advancements. Our latest innovations continue to set the standard in automated, semi-automated, and manual inspections for a wide range of applications, including conventional pulse-echo, Time of Flight Diffraction (TOFD), phased array, full matrix capture (FMC), and other advanced NDT techniques.

Our ultrasonic systems are trusted across industries such as aerospace, oil & gas, manufacturing, and power generation, offering state-of-the-art solutions for the most challenging inspection scenarios. Designed to optimize inspection processes, our products prioritize safety, reliability, and efficiency, helping you stay ahead of industry demands. With open architecture designs, our instruments provide direct access to control and data acquisition, allowing you to create custom user interfaces tailored to your specific requirements. For added convenience, highly capable off-the-shelf software solutions from UTEX Scientifics (NDT Suite) and TWI Crystal are also available for seamless integration.

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Specialized Advanced NDT & Heat Treatment Service Provider SIGMA NDT GROUP has been established in the year 1997 in Chennai with Non Destructive Testing and Certification for different industries in India. The Company's highly experienced team with their technical experience and their commitment towards quality and timely completion of tasks. The company has a wide range of advanced NDT Techniques and expects to undertake any challenging jobs.

SIGMA NDT GROUP is certified in Quality & Management Systems in ISO 9001: 2015 Our Specialization: PAUT, AUT, TFM/PCI (3D imaging with Total focusing method), PAUT at high temperatures, MFL, Specialized Heat treatment Services. Our offices are in Chennai, Mumbai, Jamnagar, Kolkata

**Contact Numbers:** 

R. K. Dey +91 99798 95022

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NDT TCIS Pvt Ltd, founded in 2008, is a leading provider of Non-Destructive Testing (NDT) solutions and equipment. Based in Rourkela, India. We focus on manufacturing and supplying advanced NDT instruments, welding inspection services, and accessories. Known for our quality and innovation, we provide products like Ultrasonic Flaw Detectors, Thickness Gauges, Leeb & UCI Hardness Testers and Industrial drones designed for specific testing needs.

Our services extend beyond equipment sales to include inspection services, consultancy, and NDT certification training. NDT TCIS also has a notable presence in international markets, supporting clients in sectors like manufacturing, construction, and oil and gas.

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A-Star Testing & Inspection Pvt Ltd is a Leading Global UTM, NDT, & Third party inspection company, Corporate Head office in Singapore and branches in India, Malaysia, Indonesia and beyond.

We have qualified Professionals Manpower of about 300 Technical Staff certified in Advanced NDT Methods, Conventional NDT Methods, also combinations of NDT with Rope Access Qualifications, and NDT with Underwater Divers.

The Company is professionally equipped to carry out Advanced NDT, Hull Thickness Surveys & Conventional NDT to various sectors such as Oil & Gas, Offshore Industries, Refineries & Petro Chemicals, Power Plants, Construction, Shipyard Industries, and other Engineering Industries.

These services are also performed by Rope Access, Rafting, and underwater which are all in accordance to top quality safety standards and are endorsed by many classification societies, Certification Bodies & Accreditation Counsels worldwide.







"spXtra" is a one stop solution provider to understand and satisfy customer needs in their inspection and NDT requirements.

Our highly competent domain experts with field experience who can understand our customer requirements better, since we believe the first step in any solution is understanding the problem.

In spXtra we provide consultancy, training, products and customised solutions to meet our customer expectation. We have our own state-of-the-art Ultrasonic Application Lab where the samples can be tested to identify suitable solution for testing.

We supply PAUT machines which are very powerful and rugged in the industry with latest TFM/FMC, PCI and 3D capabilities.

Our Ultrasonic Systems are capable with multichannel PAUT for any kind of automation and online inspection requirements.

The most advanced SPOT weld inspection solution for automobile industry is the best in class solution for any auto makers to increase their productivity and quality.

Our industrial borescopes are very advanced and unique features which meet most of the application requirements in the industries.

We thrive to keep smile our customer experience and service from each and every step ahead.





Detection Technology: The most trusted partner imaging unknown

We are a global leader in X-ray detector solutions, serving over 460 customers across 40+ countries. Our solutions power more than two billion daily inspections.

We are a preferred partner for enhancing end-user safety, quality assurance, and production process optimization with the help of powerful X-rays. Our modular and compact detectors are designed for demanding industrial environments that require the highest level of precision.

We offer the industry's broadest portfolio of standard and modular building blocks for endto-end X-ray solutions. From TDI-based, multi-view, dual-energy, to photon-counting detectors, you can choose the most suitable solution for your imaging needs. Our off-theshelf and customized detectors deliver reliability, robustness, high sensitivity with low X-ray dose, and fast scanning speeds, meeting stringent quality and throughput requirements. For people's health and safety, we equip X-rays with quality detectors and service. Our trusted solutions are the first choice for industrial, medical and security X-ray imaging. With over 30 years of experience in the field, we are recognized as industry pioneers, renowned for delivering best-in-class, locally tailored service with a global reach. With a strong presence and manufacturing in India, we're committed to offering you prompt responses and personalized support.

Let's explore how our flat panel and line scan detectors could boost your imaging applications. We look forward to serving you!



COMCO specializes in Non-Destructive Testing (NDT) solutions using X-Ray for 2D and 3D output, ensuring the safety, quality, and reliability of critical infrastructure and industrial components without causing damage. With first-of-its-kind cutting-edge technology and advanced techniques, we serve industries such as automobile, aerospace, oil & gas, EMS, casting and forging.

At the heart of our mission is safety and reliability. Our skilled technicians and engineers are committed to identifying flaws, defects, and irregularities that could compromise performance and safety. We leverage state-of-the-art tools and data-driven insights to provide clients with actionable reports that enhance operational efficiency and asset longevity.

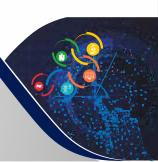
With a focus on customer-centric service, continuous innovation, and sustainability, we support our clients in minimizing risks, meeting regulatory requirements, and optimizing performance.

Whether it's new construction, routine inspections, or asset life extension, we are a trusted partner for non-invasive testing solutions that empower businesses to maintain peak safety and operational standards.

Our goal is to build trust through transparency, technical excellence, and tailored solutions for the most demanding industries worldwide.

After a lot of R&D, we have our own image stitching and 3D rendering software which is bestin-class. We manufacture our machines at Mysore, first time such machines are made in India. We are headquartered in Japan and we have our head office in India based out of Chennai.







International Reliability Services was founded in 2000. IRS is an ANAB accredited inspection Body that has established itself as a trusted leader in inspection and non-destructive testing (NDT). We serve a broad spectrum of industries, including fabrication, construction, marine, manufacturing, Automotive, Power Generation, Oil & Gas both onshore and offshore, Petrochemical and Chemical industries. IRS provides top-notch conventional and advanced NDT services, quality assurance, quality control inspection, NDT training, and consultancy services.

IRS's team of certified and experienced professionals is dedicated to upholding the highest standards of safety, excellence, and innovation. This commitment ensures that IRS consistently delivers reliable and high-quality services that set industry benchmarks. In addition to our core services, IRS offers a full range of heat treatment services, flange management services such as bolt torquing, bolt tensioning, and flange face machining, heat exchanger tube cleaning services, and rope access maintenance and repair services. These diversified capabilities allow IRS to meet the varied and complex needs of our clients, further solidifying our reputation as an industry leader.

Our NDT Services includes:

Conventional NDT Services: MT, PT, UT, RT, VT, PMI-XRF & OES, FT, HT,

Advanced NDT Services:

PAUT, TOFD, AUT, LRUT, SRUT, PEC, ACFM, ECT, MFL, MRT, IR, AET, DR, GPR, Holiday Test, Tube Testing - ECT, RFT, IRIS, NFT, ECA, RFA, MFL

Heat Treatment Services: PWHT, Pre-Heating



Aerica Engineering Pvt Ltd: Delivering Innovative NDT Solutions

Established in 2014, Aerica Engineering Pvt Ltd is a dynamic company dedicated to manufacturing, customizing, and supplying cutting-edge products for Non-Destructive Testing (NDT). As an ISO 9001:2015 certified organization, we uphold the highest standards of quality and excellence.

# Our Commitment:

Unique and Advanced Products: We specialize in creating unique and advanced NDT solutions that address industry-specific challenges. Our products are designed to enhance inspection processes, improve efficiency, and ensure safety.

# **Customized Solutions:**

At AEPL, we understand that every client's needs are different. Our team of highly experienced and trained professionals collaborates closely with clients to provide tailored solutions that meet their specific requirements.





SEC, established in 1991, based on over 29 years of accumulated technical know-how, we have been continuously developing backbone of e-beam inspection equipment in Korea.

SEC has been manufactured LINASEC® System which is All-in-One type, which includes all necessary components like Linear accelerator, RF generator, high frequency modulator, HVPS, shielding, power supplies, interfaces.

SEC's accelerator product line consists of a broad range of S-band accelerators providing a variety of doses, energies, and focal spot sizes. For security application that requires material discrimination, SEC offers dual energy interlaced accelerator at 6MeV and 9MeV



U-Sonix is an ISO 9001:2015 certified company established in 2005, primarily, as an "Advanced Non Destructive Testing (ANDT) center". We are also an Olympus Approved Training center.

We are pioneers in the field of Advanced Ultrasonic Testing (AUT) and specialize in Phased Array Ultrasonic Testing (PAUT) and Time Of Flight Diffraction (TOFD). We have successfully implemented the AUT technique (PAUT & TOFD) in a number of projects, worldwide. Additionally, we provide other Advanced NDT services such as Auto UT, Corrosion Mapping, Boroscopy etc.

We provide services to the Oil, Gas, Offshore, Marine, Power, Wind energy sector, Petrochemical sector, and Nuclear sectors

In a span of 20 years, we have provided services to major clients like Shell, GE, Saudi Aramco, Saipem, ONGC, Qatar Petroleum, PDO Oman, Aker Solutions, Tekfen, Reliance Industries Ltd, Worley Parson, Foster Wheeler, Alstom, RINA, Applus Velosi, Oryx, SapuraKencana, NPCIL, LTHE, Tata Power, Vedanta, NTPC, IOCL, MRPL, HPCL, BPCL etc. for many of their premier projects, worldwide.

All the activities and services are carried out using sophisticated & state of art equipment, combined with latest technology available, globally, backed by a team of qualified and experienced professionals with specific focus and attention to Quality and work safety.







To be the preferred service provider in Non Destructive Testing (NDT) and Materials Testing. To deliver to our customers the best possible service in terms of technical support, timeliness and value.

SITAS as known to our clientele, we are the pioneers in the field of Non Destructive Testing. We stand apart with the distinction of being one of the few companies in India to usher in sophisticated techniques in NDT. SITAS established in the year 1979 has focused its presence all over India and Middle east with branches and onsite locations in Bangalore | Coimbatore | Shimoga | Hubli | Sangli | Bellary | Mysore | Ahmedabad | Delhi | Mangalore | Kolhapur | Abu Dhabi | Dubai | Doha

We are the only Indian NDT company to be accredited by Transport and Power Generation Accreditation Program(TPG) by Performance Review Institute (PRI) Warrendale, USA.

Having reached 42 years in the industry successfully, our mission is to emerge as the leader in NDT, offering Advanced as well as Conventional NDT methods using State-of- the-art equipment, effectively and efficiently.

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Microlab has been a trusted partner to various industries, consistently meeting the rigorous quality standards required by critical sectors.

Our technical expertise is backed by a highly skilled team adept at advanced testing methodologies, including failure investigations using Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Analysis (EDX). These capabilities have been deployed successfully in collaborations with key stakeholders in Defence, Navy, Aerospace, Automotive, Oil & Gas, Heavy Machinery, and related sectors.

Microlab has had the privilege of serving esteemed organizations such as Siemens, VSSC, HAL, MIDHANI, Bayforge, and L&T Defence. Attached herewith are purchase orders from these clients as evidence of our contributions, particularly in the Aerospace sector. Additionally, our services extend to NPCIL, BHEL, and DGQA, with notable involvement in component indigenization projects for 8BRD. Currently, we are also engaged with CVRDE on reverse engineering for critical castings.





Afcons Infrastructure Ltd is flagship infrastructure engineering and construction company of the Shapoorji Pallonji Group. It has a legacy of over six decades, with strong track record of executing numerous technologically complex EPC projects both within India and internationally. As per the latest ENR survey, Afcons is ranked in Top 120 international Contractors globally; 10th in Marine & Ports and 12th in Bridges.



Acoustic Control Systems – ACS Group – established in 1991 – is the international provider of innovative ultrasonic testing equipment and professional inspection and engineering services.

The definitive distinction of ACS products is their high technological level and ease of use, matching the requirements of professional users in a wide range of practical applications. The main goal of our instruments is to reach top technical characteristics by affordable costs in combination with the perfect warranty service and methodical support of our customers.

Besides developing, manufacturing, and distributing novel testing instruments and systems, ACS Group offers highly professional and innovative inspection services on infrastructural concrete and metallic objects – all over the world. We have introduced ultrasonic to mography in non-destructive testing and our customers benefit from the quantitative evaluation of inspection results with modern 2D and 3D imaging. More than 30 years of in-field testing experience in combination with scientific signal and image processing techniques and modern manufacturing processes by using the best components available on the market allow ACS to be always technologically one step ahead of competitors.



We are exclusive authorized distributor of ACS, Germany, Controls S.P.A, Italy. including Soil Division of Wykeham Farrance and IPC Global in India. Our company is a dynamic marketing and distribution channel marked by Growth, Innovation and Stability. The definitive distinction of ACS products is their high technological level and ease of use, matching the requirements of professional users in a wide range of practical applications. The main goal of our instruments is to reach top technical characteristics by affordable costs in combination with the perfect warranty service and methodical support of our customers. ACS Group offers highly professional and innovative inspection services on infrastructural concrete and metallic objects – all over the world. We have introduced ultrasonic tomography in nondestructive testing and our customers benefit from the quantitative evaluation of inspection results with modern 2D and 3D imaging.

Product: Thickness Gauges, Flow Detector, EMAT-HT, SOLO, MIRA, Pulsar...







Established in the year 2005, ZChem Specialities came a long way to become a full Range NDT company in the areas of Liquid Penetrant Inspection (LPI) and Magnetic Particle Inspection (MPI). Promoted by two experienced Technocrats turned Entrepreneurs, it is one of the few companies in the world offering a complete range of products in consumables and equipment. With a manufacturing facility in Bangalore, India, ZChem currently operates Pan India, Middle East ASEAN, and African countries.

All products in Magnetic Particle Inspection & Liquid Penetrant Inspection Techniques. Backed by unique technology, ZChek products are manufactured using world class manufacturing facility, with vital combination of vision to grow, commitment to offer value to the customer and over 50 years of management competence, we are the unique choice for our customers.

Zchem has a strong professional team capable of developing and offering customized products and solutions for various industrial applications. All ZChek products are designed to meet the most stringent requirements of the industry norms across the globe.

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SG NDT Inc. offers the latest technology available on the market for eddy current non-destructive testing. Cutting-edge products developed for your needs

SG NDT is also...

... original equipment manufacturing (OEM) services
OEM manufacturing means selling the electronics and packaging it as your product.

Discover our range of original equipment

S2G2-WS OEM - 512 channel ECA equipment

OEM device ready for integration

nS2G2-OEM

Develop your own inspection device for steel or cast iron with multi-element far fields

□S2G2-OEM

Your solution for truly portable 64-channel ECA equipment.

Through innovation, we surpass standard expectations





Radent Engineering, based in Chennai, is a leading manufacturer, supplier, and exporter of Non-Destructive Testing (NDT) equipment and accessories, specializing in Ultrasonic Testing, Radiographic Testing, Magnetic Particle Inspection (MPI), Eddy Current Sorters, Dye Penetrant Consumables, and more.

With over two decades of industry experience, Radent Engineering is committed to delivering high-quality products and exceptional after-sales service.

The company is ISO 9001:2015 certified and is known for its reliable, cost-effective solutions. Their extensive product range caters to various industries, including automotive, forging, heavy engineering, fabrication, railways, defense, aerospace, and more. Radent serves over 2,500 customers both in India and internationally.

Radent Engineering provides Annual Maintenance Contracts (AMCs) to minimize downtime and ensure high-quality inspections. Their detailed preventive maintenance (PM) records help identify potential issues, such as machine wear or operator misuse, and provide essential data for certification and documentation.

Radent Engineering customizes equipment to meet the specific needs of each customer. Customers value Radent's product quality, design, and commitment in meeting industrial standards while maintaining quick turnaround times on repairs.

Radent Engineering's core values include:

- Reliable quality with advanced technology
- Adherence to industrial standards
- Cost-effective solutions within stipulated timeframes
- Prompt repair services

For more information kindly visit our website: http://www.radentndt.in/ and https://www.indiamart.com/radent-engineering/



SANTRICALS is providing NDT Instruments Distribution – Manufacturing – Inspection Services – Calibration and Repairing Services – Annual Maintenance Contract Services and Onsite NDT Training Services for Professionals.

In addition we are involved in Automation turn key projects – Design and Development of NDT Automation Systems – Customized NDT Solutions. We are authorized distributor for various OEM in UT – ECT – RT – MPT – Instruments and Accessories.

We are specialized in manufacturing of High Intensity LED Film Viewers, UV Light, Nylon Braided Ultrasonic Cables, Magnetic Yokes, Standard Ultrasonic Cables etc.,





Our Major products are Ultrasonic Flaw Detector – Phased Array Ultrasonic System – Ultrasonic Probes – PAUT Probes – Soft Tip Probe – Wheel Probes – Bond Testers – Scanners – Pre-Amplifiers – High Power Amplifiers – Ultrasonic Thickness Gauges – Eddy Flaw Detectors – Smart Scan System – Eddy current Conductivity Meter – LRUT Systems – Hardness Testers – Calibration Blocks – Digital Radiography System – X-Ray Sources etc.,

Our focussed Industries are Aerospace – Power – Oil & Gas – Steel – Fertilizers – Automative – Construction & Infrastructure – Aviation – Renewable Energy – Chemical – Railways – Wind Blade Manufacturers – Educational Institutes – Shipyards etc.,

We have a strong technical team to take care of after sales support activities. We have a qualified NDT Inspection team to carry UT – ECT – MPT Inspection jobs. For more information you can visit our website www.santricals.com. For your queries please send an email to pport@sdrgroups.com.

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MQS Technologies is an Indian Engineering company specializing in Digital Industrial X-RaySolutions including Computed Tomography. With our multi- domain expertise, we offer tailormade solutions for a wide range of industries. Our offerings ranges from standalone X-raysystems (Mini, Micro, Nano) to High Energy systems along with multi-axis manipulators that are used for non-destructive evaluation in production, assembly and quality assurancedivisions. Also we have catered the radiography testing requirements of various critical projects in a wide range of industries.



INDIA's FIRST TERAHERTZ COMPANY. TeraLumen Solutions, with its roots firmly planted in Indian soil, is a beacon of global excellence as a provider of medical-grade Terahertz diagnostics products, Industrial-grade Terahertz testing solutions and research-grade THz systems for a diverse array of markets.

At TeraLumen Solutions, we are committed to providing world-class terahertz technology solutions that bring measurable value to our customers. Our industrial terahertz systems are designed to deliver precise, non-destructive testing (NDT) and advanced inspection capabilities that enhance efficiency and quality across multiple industries.





SK Technologies has been leading the way in advancing Non-Destructive Testing in India into various Government and Private Sectors. We expertise in Non-Destructive Testing Services and Products which stands for quality and reliability.

SK TECHNOLOGIES believes in providing best inspection services related products as well as services to their customers. SK TECHNOLOGIES have a highly experienced panel of Inspectors who are conversant with the latest product specifications and have the competence to meet the ever-changing needs of the customer's specifications. Our dedication to quality, integrity, and customer satisfaction guides every decision and action we take.

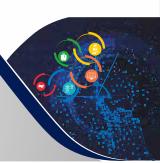
Our mission is to achieve and maintain the highest level of customer confidence and satisfaction, by providing uncompromising quality standards in executing a given task, through a team of well qualified, experienced and competent Inspectors, combined with state-of-the-art technology.

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An Avail Infrastructure Solutions Company

WSI, an Avail Infrastructure Solutions company, is the world leader in delivering specialized installation and maintenance solutions through automated welding. We are the industrial and nuclear markets' most sophisticated automated specialty welding contractor. Founded in 1978 and with locations worldwide, WSI is the industry leader in automated repairs for pressure equipment. Our industry experience, global presence, and best-in-class execution are key to delivering improved plant reliability safely and effectively. WSI is known as the world leader in pressure equipment life extension, and provides automated welding, weld cladding, weld overlay, high velocity thermal spray, and combinations of these technologies that extend the life and maximize the value of assets throughout the energy industry. WSI is the premier singlesource contractor capable of providing a comprehensive range of corrosion/erosion mitigation services. We offer engineered solutions that provide the best possible outcome and the most appropriate solution to your unique problem. As the largest and most experienced provider of component critical installation, repair, and life extension services, WSI delivers solutions to address planned and emergency response solutions to many of the largest international companies in energy industry. WSI can improve your unit's return-on-investment, while safely reducing risk and improving equipment availability and performance. Recently, WSI inaugurated its India facility in Vadodara to address and deliver unique repair solutions to Indian Clients, enabling quicker response times and localized expertise. WSI India is keen to collaborate with the Indian Energy sector to extend the life of various equipment and improve your plant's operational efficiency.







Folium Sensing Pvt. Ltd. is a pioneering company specializing in advanced sensing technologies that utilize optical fiber cables for real-time monitoring and analysis. Our focus lies in developing innovative solutions for Distributed Acoustic Sensing (DAS), Distributed Temperature Sensing (DTS), and Fiber Bragg Grating (FBG) systems, which cater to a wide range of industrial and infrastructural applications.

DAS technology transforms standard optical fibers into sophisticated acoustic sensors capable of detecting vibrations and sound over long distances. Its applications include pipeline leak detection, seismic monitoring, and perimeter security. By offering a distributed sensing approach, DAS provides continuous and accurate data, ensuring proactive measures in critical scenarios.

DTS systems leverage optical fibers to measure temperature variations along their length, making them ideal for fire detection in tunnels, monitoring power cables, and managing thermal profiles in industrial processes. This technology is particularly valued for its precision and resilience in harsh environments.

FBG technology utilizes embedded gratings within optical fibers to sense strain, temperature, and pressure with high sensitivity. It is widely used in structural health monitoring of bridges, buildings, and dams, as well as in aerospace and medical instrumentation.

At Folium Sensing, we aim to address the world's growing need for intelligent and efficient sensing solutions. Our technologies are tailored to enhance safety, efficiency, and sustainability across diverse domains, driving innovation and empowering industries with actionable insights. We envision a smarter future powered by fiber-optic sensing.\*\*





ARIMA brand products are x-ray-based imaging and analysis instruments. The x-ray source and associated systems are designed and developed in India. The company at present focuses on digital x-ray imaging and solutions. The company is located at Coimbatore in Tamil Nadu, India. With a 20 strong engineering team, design is our forte and we are able to provide customised solutions to customers in various industries.



Octobotics Tech Pvt. Ltd. is a leader in robotic solutions for Non-Destructive Testing (NDT) across critical industries, including marine, oil & gas, chemical, and steel sectors. Headquartered in Noida, India. Octobotics combines cutting-edge technology with industry expertise to deliver autonomous inspection solutions that prioritize safety, precision, and operational efficiency in challenging environments.

### Our flagship products include:

Weld Sensei: An autonomous crawler for weld scanning using TOFD/PAUT, designed to provide high-precision inspection of welded joints.

Gauge Rover: A versatile robotic solution that performs both surface preparation and thickness gauging, making it ideal for managing asset integrity.

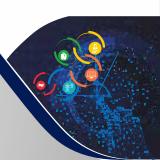
Track Sense: Specialized for corrosion mapping and weld overlay inspection, this crawler enables comprehensive structural assessment, helping prevent critical failures.

ReachMaster™: A telescopic pole-mounted solution for thickness gauging, allowing safe and efficient inspections in confined or hard-to-access areas.

These advanced solutions serve key sectors such as shipping, offshore facilities, heavy engineering, and oil & gas. Octobotics Tech also provides a range of specialized services, including robotic surface preparation, pipeline integrity assessment, and automated quality control, all designed to optimize maintenance and safety protocols.

Our commitment to quality is reinforced by ISO 9001:2015 certification, and our products are trusted by leading certification bodies, including ABS, IRS, and ClassNK. With a mission to redefine NDT through robotic autonomy, Octobotics Tech continues to push the boundaries of inspection technology, setting new benchmarks in safety, precision, and efficiency.







Bell O Seal Valves (P) Ltd having its State-of-the-art Manufacturing plant at Udupi, Karnataka State is a 33year-old company, manufacturing High Quality Bellow seal valves with an annual production capacity over 45,000 Valves from Sizes ½"(15mm) to 26"(650mm) with ratings Class 150# up to Class 2500#. Our Valve Manufacturing unit is spread over an area of 100,000 sq. ft. allied with infrastructure of dedicated teams related to Admin / Sales / Design / Planning / Production / Testing / Quality / Painting and Dispatch. Apart from our Valve manufacturing unit, we have our own Foundry to cast valve parts. All Bellow welding's of Bellow Seal Valves are done with state-of-the-art Laser welding machines. . All Bellow Welding and satellite deposition are done by our NPC / TUV / IBR approved qualified expert welders. All Bellows after welding are Helium Leak Tested in-house on Mass Spectrometer Leak Detector (most sophisticated and advanced machine). All Bellows are designed to EJMA requirements and calculation of length suitable for minimum 20,000 cycles is taken into consideration. Bellows are stress free while assembly and when valve is fully in operation (closed position). Other typical applications of our bellow seal valves include: Thermic Fluid, Ammonia, Cryogenic, Phosgene, Butadiene, Benzene, Ethylene, Hydrogen, Steam, Fatty acid, HF to name just a fraction of the many possible uses. Having gained an experience in delivering reliable bellow seal valves over the last 30 years, BOS group has diversified into manufacturing other types of industrial valves.

# Mitcorp

Mitcorp embodies a new approach to non-destructive inspections.

We believe that innovative Videoscopes should be accessible to all needing them. We challenge the view that reliable and accurate inspection products should be so highly-priced that they become impractical for hard-working business owners.

Instead, we think that the best technology should benefit our customers' practical, everyday business needs.

Working closely with our clients since 2003, Mitcorp embodies a passion for innovation and has accumulated over 180 patents since becoming independent of the Chung Shan Institute of Science and Technology, Taiwan. Certified by the well-known vehicle brands Audi, Skoda, VOLVO, and Volkswagen, Mitcorp has proven to be a reliable partner with a strong focus on its end users.

With a highly agile approach to business and a reputation for the very highest levels of quality and dependability amongst our key distributors, we seek leadership within nondestructive inspection providers worldwide.





NDTS India was established in 2007 with a motive to build a professionally managed enterprise dedicated to the challenging field of Non-Destructive Testing (NDT) & Evaluation. Today, we are an ISO 9001:2015 certified company offering 24/7 On-site NDT Services by deploying world-class equipment's with trained manpower as per various affiliations (ASNT, ISNT, ISO etc.).

At NDTS India, we constantly endeavor to fulfil our customer's varied inspection needs and are deeply committed towards surpassing their expectations. We value and cherish their valuable suggestions and assistance. By virtue of our focus, core competence, a committed team of professionals and our unrelenting quest for excellence, we are fully geared to meet current and future challenges.

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DNDT Technologies OPC Pvt. Ltd. has been in the business of manufacturing high quality UV products since 2016. We are focused on providing most optimal solution to the customers with our expertise in the field of UV Light.

We always try to be true to our customer's expectations with our quality products, such as DNDT UV-A LED Torch

DNDT UV-A LED Hand Lamps (Both AC and Battery Powered)

DNDT UV-A LED Over head Lamps.

We also provide Hand Lamps and Overhead Lamps complied to latest API and ASTM E-3024 specifications.

We at DNDT believe in providing standard as well as customized UV product solutions to our customers with our innovative approach. DNDT products are of the highest quality and easy to use.

Prompt after sales service has always been our main focus and has helped us in strengthening our relationship with customers.

We have a diverse esteem customer base with presence in Automotive, Oil and Gas, Aerospace, MRO, Pharmaceuticals, Manufacturing, Railways, defence, electronic components and Nuclear Power.

DNDT thrives to work 24\*7 for the development in the field of UV technology as well as NDT.







Plasma and Vacuum Technologies (PlasVac) was founded in the year 1997, at Diamond Park, GIDC Naroda, Ahmedabad. In the year 2008, the company moved its activities to GIDC, Kathwada, Ahmedabad. PlasVac is ISO 9001:2015 accredited firm for its activities of : a) carrying out Vacuum & Leak Testings (BT, PCT and HLT) as per standard NDT codes and procedures; b) Vacuum Brazing; c) Vacuum Drying; d) Vacuum Heat Treatment; e) Plasma Nitriding; and f) Fugitive Emission Testing of Valves as per API and ISO15848 codes. In addition, PlasVac conducts regular Training programs for Vacuum & Leak Testing for certifying professionals in NDT-LT under the leadership of Dr Venkat N. Ramani, ASNT LIII in NDT-LT, Proprietor of PlasVac.

PlasVac also runs an ISO17025:2017 Calibration Laboratory for Vacuum Gauges and Helium Standard Leaks. The NABL accredited Calibration Laboratory serves Industries and Research organizations in India, since May 2018, in the calibration of Vacuum Gauges in the range 1000 to 1e-6 mbar and in the leak rate range 1e-1 to 1e-9 Std cc/s. Within the scope of ISO9001-2015, PlasVac performs calibration activities for a) Gas Flow Rate Measurements in vacuum; b) Permeation Rate for vacuum barriers; c) Outgassing Rate for materials in vacuum; d) Pumping Speed of Vacuum Pumps; e) Conductance of Vacuum Components; and f) Gas composition in Mixture of gases.

Beginning from January 2025, the PlasVac activities will be merged with those of M/S Aditya High Vacuum Pvt. Ltd.

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With over two decades of industry leadership, Qtech Inspection Services has been a trusted name in Non-Destructive Testing (NDT), offering comprehensive inspection and training solutions tailored to the evolving needs of the industry. Specializing in advanced NDT methodologies, including dye penetrant testing, radiographic testing, ultrasonic testing, and magnetic particle testing, we ensure the highest standards of safety, precision, and quality across diverse sectors.

Our commitment to excellence extends beyond traditional NDT services. As an IRATA (Industrial Rope Access Trade Association) approved training and service provider, Qtech Inspection Services now offers world-class rope access training and operations. This addition enhances our capabilities, allowing us to access complex, high-risk environments safely and efficiently, while delivering the same high-quality inspection results our clients have come to expect.

Our team of experienced Level III inspectors and certified IRATA trainers are dedicated to empowering the next generation of NDT professionals. By integrating cutting-edge technology with industry-leading expertise, Qtech Inspection Services ensures accurate, reliable, and timely results, while maintaining the highest standards of safety and compliance.

As we continue to grow, our focus remains on delivering exceptional service, cultivating a culture of continuous learning, and upholding the integrity that defines our legacy. Qtech Inspection Services—your partner in precision, safety, and innovation for over 20 years.





Pradeep Group of Companies, established in 1975 as manufacturing of following NDT products. Presently it has three manufacturing units at Thane and Pune in Maharashtra State in India.

- 1. Dye Penetrant Testing Consumables
- 2. Magnetic Particle Testing Consumables

3. Leak Testing Consumables

4. Accessories for Non Destructive testing.

Our Company has state of art manufacturing facilities and the products are manufactured under strict supervision and by qualified personnel. Company has in house testing facilities. The laboratory is fully equipped with all the required equipments and personnel to test the products to confirm meeting the requirements of all theinternational specifications in the field of NDT. The Company is ISO 9001-2015 certified and the products and manufacturing facilities are also certified by Research Design and Standards Organisation of Indian Railways (RDSO) and Nuclear Power Corporation of India Ltd(NPCIL) for use of products in Railways and for Nuclear applications respectively. The products manufactured by us are nontoxic, Bio-degradable and are made by using environment and Operator friendly ingredients. These products are well accepted all over India by Govt & Pvt Sector industries and by well known inspection authorities such as Lloyds, ABS, IRS, BV, Udhe, Jacobs, Rites, RDSO, NPCIL, EIL etc. Company has dealers network all over India and abroad for supply of the products to users in India and to different countries.

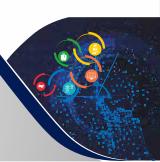
Factory/Office Locations in Maharashtra Pradeep MTC Pvt.Ltd. Wagle Estate, Thane Pradeep NDT Products Pvt,Ltd.Kondhwa Pune Qualitech Engineering Services, Pune Ukaas Consultancy Pvt.Ltd., Thane

QNET

Quality Network Pvt Ltd

One of the NDT service Provider in India Since 1996 in the field of Power, Petrochemical and Refinery with the facilities of Ultrasonic Testing, DPT, MPI, Hardness Measurement, In-situ Metallography, Oxide Scale Thickness Measurement, Natural Frequency Testing, Borescope Inspection, Eddy Current Testing, Positive Material Identification, Failure Analysis Investigation and Accelerated Creep Rupture Testing. Our team consists of well experienced Level II and Level III qualified engineers with exposure to boiler, turbine, generator components and in refinery components. Our major clients are NTPC, DVC, NALCO, TANGEDCO, CPCL, NTECL, NSPCL, GE Power, Powermech, Siemens and many more.







Maarg is the word for path in many Indian languages. Our vision is to reach to every one who looking for advanced yet economical Remote Visual Inspection (RVI) solutions.we take pride in delivering suitable, competitive, RVI Solutions to the needs of the all verticals of the Industries from Automotive, casting, Process, Aerospace, Nuclear, Power Etc. We committed to help and support our existing and prospective customers by all possible means.Means we have Quality and variety for every RVI-applications need. We are continually evolving and emerging as an Economical & Best Quality RVI Solution providing company.

.....



Aditya International Co. established in 1999 with an objective is to become a one stop shop for all innovative engineering products for the customers and also establishing ourselves as a market leader in the field of industrial engineering and maintenance.

Aditya International Co. Provides MRO solutions to meet the demanding maintenance requirements of the industry. Our professionally trained engineers are ready to serve & assist you in indentifying the trouble spot in your equipment to jointly & proactively solve your MRO problem. And ultimately to help in reducing your maintenance to improve the overall reliability of your equipment working under hostile condition.

To offer the best innovative solution to each industry segment, Aditya International Co. Operates the following divisions that are branded uniquely for the most prominent recognition by users and customers

Aspen Aerogels- USA -Thermal Insulation Blankets for Hot & Cold Services
Mascoat Thermal Insulation coating
ITW PP& F- Maintenance Consumables
PEWAG- Lifting Solutions
Garlcok Sealing Technologies
Intercept-Copper based Corrosion Protection Technology
Plarad-High Torque Bolting Solutions





KappaWave was founded in 2015 to build and deliver highly advanced, easy to use and affordable Ultrasonic Testing instruments meeting international standards for quality. KappaWave's primary focus has been building quality NDT instruments with an emphasis on usability. Our machines undergo thorough testing by experienced UT professionals to ensure compliance to industry standards. Kappawave's instruments are world class units produced in the state of Kerala in India. They are economical, easy to operate, reliable, and truly stateof- the art. For more information please see https://kappawave.com/ or call John on 9447705887.

### KappaWave

454, Karukancheril, Kiliroor (N) P.O., Kottayam 686020, Kerala, India.

Tel: 9446426305, 9447705887

Fax: N/A

Email: sales@kappawave.com Contact Person: P.K. John Website: www.kappawave.com



Magnafield Controls, started in 1972 were the pioneers in manufacturing MPI machines in INDIA. The company has since indigenously designed and manufactured more than 7000 MPI machines and related systems, in India and abroad. We have also conducted various training programs for customers in India and abroad. The company has also developed a one of a kind, dedicated software for recording of data for tested parts in MPI process for quality assurance. Currently all the business activities are carried out by Vinze Magnafield Controls under the proprietorship of Mr. Mandar Vinze along with its sister concern KM Qualitech Controls started by Mr. Mihir Vinze.

Our activities include and are not limited to the following –

- 1. Design and Manufacture of custom made semi automatic MPI & handling systems as per specific customer requirements.
- 2. Developing of data recording software.
- 3. Manufacturing of standalone, continuous duty conveyorised demagnetizers.
- 4. Overhaul/reconditioning of any make of MPI systems.
- 5. Supply of all accessories and consumables related to MPI.
- 6. MPI testing services on contract basis.
- 7. Calibration services.
- 8. Consultancy/Audit of MPI systems and procedures.
- 9. Operator focused specially designed training programs in MPI.

Our Motto -

**Detecting The Undetectable** 

NDT Excellence in Quality - Dependability-Precision







With over 25 years of experience in the NDT market, Varex Imaging NDT Solutions is a premier manufacturer and developer of a wide range of digital imaging equipment and software solutions.

Our highly experienced application and technician teams allow us to provide high-quality support to our customers in markets including oil and gas, nuclear, military, aerospace, automotive, casting, manufacturing, and many more.

.....



Squaremag Systemssupports ambitious companies to establish world class Automotive & Aerospace infrastructure. We provide Turnkey Industrialisation inDesign, manufacturing, installation of Non-Destructive Testing Equipments& Special Process lines like Pre- cleaning, Anodizing, Electro Plating&Spray Painting.

We are being promoted by a team of manufacturing professionals with over 30 years of Industrial Expertise and have successfully setup facilities across the country compliant to ISO-TS-16949, AS9100, NADCAP, MIL and AMS, ASTM Specifications and Standards.

### Our portfolio includes:

- Pre-Cleaning (Ultrasonic, Vapor degreasing, pre-treatment)
- Magnetic Particle Inspection
- Fluorescent penetrant inspection
- Post cleaning
- Surface finishing/Treatment
- Spray Painting



# VJ Imaging Technologies 😈

VJ Imaging Technologies (VJIT) is VJ Technologies' (VJT) operation in India. VJT was founded in 1987 and is a global leader in providing Digital Radiography (DR) and Computed Tomography (CT) X-Ray Inspection System and Solutions for a variety of industries ranging from aerospace and automotive to food and nuclear.

For over 35 years, VJT's visionary and talented engineers have developed groundbreaking solutions in the field of non-destructive testing (NDT). Through VJT's experience it has led to innovative decisions and more advanced capabilities than competitors in our standardized systems. Our imaging systems are used throughout the world for radioscopic inspection of products and assemblies to detect defects for foreign matter, reducing cost and time while increasing quality and safety.

VJT is part of the VJ Group along with our sister companies VJ Electronix (VJE) and VJ X-Ray (VJX) collectively deliver confidence by providing a comprehensive range of innovative inspection systems, solutions and services that positively impact the lives of people around the world. Together with the divisions of VJ Group, VJT delivers a competitive advantage and superior customer service to companies through our network of global offices.

VJ Imaging Technologies Pvt. Ltd. Address: Plot Number 5&6,

Aerospace SEZ, Bangalore-562129

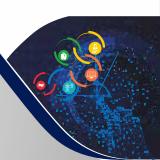
Website: www.vjt.com Email: vjitsales@vjt.com

Phone: +91 (80) 4113-8649 / +918277585715



Precision Equipments, the pioneer in the field of manufacturing & supply of Shell and Tube Heat Exchangers since 1981 was established with a clear vision to provide end to end solutions to their customers in the process industry such as Oil & Gas, Petrochemicals, Fertilizers, Chemical, Power Plants, Energy & Nuclear. The company with an employee strength of 400+ and an annual turn over of 25 Million USD has consistently grown with its rich experience in the process industry. Since its inception, the company has designed and manufactured over 3000 Process Equipment for Oil and Gas, Petrochemical, Fertilizers and Energy Sector for its Customers in India and International Market.







Scanflow.ai, operating for four years is a subsidiary of Optisol Business Solutions our parentcompany with 16 years of experience in the IT services industry has been transforming industries with Al-driven scanning solutions. At the core of our offerings is Visual Inspectionfor Quality Control, leveraging advanced object detection to identify defects in real time, ensuring superior product quality while minimizing operational downtime.

Our solutions address diverse use cases, from detecting surface anomalies on manufacturinglines to ensuring precise assembly in complex production processes. In addition to qualitycontrol, we provide Barcode and QR Code Scanning for enterprise-grade data capture, seamlessly integrating with smart devices such as smartphones, tablets, and smart glasses.

Our Inventory Management solutions streamline goods tracking and optimize operationalworkflows. Designed for flexibility, Scanflow's solutions can be deployed via the Cloud forscalability or at the Edge for low-latency applications, catering to a wide range of operationalneeds. For hard-to-reach areas, we enable integration with drones and other innovativetools, ensuring every aspect of the production process is monitored with precision.

Through these capabilities, we empower businesses to achieve unparalleled qualityassurance and operational efficiency.

.....



Wadhwani Electronics Laboratory (WEL) was inaugurated on February 12, 2001, in the Department of Electrical Engineering, IIT Bombay supported through an endowment from our distinguished alumnus, Dr. Romesh Wadhwani (EE 1969). More than 1,700 students use WEL each year for laboratory courses and projects. WEL cultivates a vibrant community of highly capable and passionate engineers and research assistants that continually demonstrate excellence through developmental activities. Students and staff working at WEL have made numerous contributions through innovative projects, academic and industry recognition, and translational impact



One of the NDT service Provider in India Since 1996 in the field of Power, Petrochemical and Refinery with the facilities of Ultrasonic Testing, DPT, MPI, Hardness Measurement, In-situ Metallography, Oxide Scale Thickness Measurement, Natural Frequency Testing, Borescope Inspection, Eddy Current Testing, Positive Material Identification, Failure Analysis Investigation and Accelerated Creep Rupture Testing.

Our team consists of well experienced Level II and Level III qualified engineers with exposure to boiler, turbine, generator components and in refinery components.

Our major clients are NTPC, DVC, NALCO, TANGEDCO, CPCL, NTECL, NSPCL, GE Power, Powermech, Siemens and many more.

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Raillabs is on a mission to revolutionize railway safety through cutting-edge digital technologies.

In today's rapidly evolving world, ensuring the safety of rail transport has never been more crucial. However, outdated monitoring systems and reliability issues continue to pose significant challenges.

At Raillabs, we see these challenges as opportunities for innovation, driving us to push the boundaries of what's possible in railway safety technology.





With over two decades of industry leadership, Qtech Inspection Services has been a trusted name in Non-Destructive Testing (NDT), offering comprehensive inspection and training solutions tailored to the evolving needs of the industry. Specializing in advanced NDT methodologies, including dye penetrant testing, radiographic testing, ultrasonic testing, and magnetic particle testing, we ensure the highest standards of safety, precision, and quality across diverse sectors.

Our commitment to excellence extends beyond traditional NDT services. As an IRATA (Industrial Rope Access Trade Association) approved training and service provider, Qtech Inspection Services now offers world-class rope access training and operations. This addition enhances our capabilities, allowing us to access complex, high-risk environments safely and efficiently, while delivering the same high-quality inspection results our clients have come to expect.

Our team of experienced Level III inspectors and certified IRATA trainers are dedicated to empowering the next generation of NDT professionals. By integrating cutting-edge technology with industry-leading expertise, Qtech Inspection Services ensures accurate, reliable, and timely results, while maintaining the highest standards of safety and compliance.

As we continue to grow, our focus remains on delivering exceptional service, cultivating a culture of continuous learning, and upholding the integrity that defines our legacy. Qtech Inspection Servicesâ€"your partner in precision, safety, and innovation for over 20 years.



### **INSIGHT QUALITY SERVICES**

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Email: support@iqs-ndt.org Website: www.iqs-ndt.org



#### TRAINING COURSES

- API Preparatory (510, 570, 653, 580, 936, 577, TES, 571, 1169, SIRE, SIFE, 579)
- Preparatory for NDE Level III (Basic, PT, MT, UT, RT, VT, LT, ET)
- TUV Nord approved for ISO 9712 Training (PT, MT, UT, RT, VT)
- TWI approved for CSWIP 3.0, 3.1, 3.2, Bgas Training
- · AWS approved agent for AWS CWI, & SCWI Seminar & Exam
- IS 13805 Training for Level II / III (Basic, PT, MT, UT, RT, VT, LT, ET)
- ICN ISO 9712 Level 2 & 3 Preparatory for (PT, MT, VT, UT, RT)
- . NDE Level I / II Certification Training for (PT, MT, VT, UT, RT, ET, LT)
- Teternel Auditor terining for TCO 0001 TCO 1400 TCO 45001
- Internal Auditor training for ISO 9001, ISO 1400, ISO 45001
- Awareness Training for BS EN 1090, ISO 3834, ISO 15085, ISO 17025
   AD 2000 HP 01
- Code Awareness Training for ASME, API, ASTM, ISO, AWS, SSPC
- Welding inspectors / Welders, QC managers' certification
- . The IQS Bridge (Training Program in Welding & NDT)
- Hybrid Training & Computerized mock-up exams for API, AWS & NDE Level III modules

### NDT SERVICES

- NDE services for VT, PT, MT, UT and RT film interpretation by NDE Level II / III
- EN ISO 9712 Level 2 / 3 services for (PT, MT, UT, RT, VT)
- · PCN PAUT & TOFD Level 2 / 3
- Hardness Testing, Borescope & PMI Inspection

#### CONSULTANCY SERVICES

- ASME Certification (U, R, U2, S, N, PP Stamps) Preparatory work
- ISO 9001, ISO 14001, ISO 45001 Certification work
- BS EN 1090, ISO 3834 & ISO 15085, ISO 17025 & AD 2000 HP 01 Certification preparatory work
- · API 20 D, 6D, 6A, 16A, API Q1 Certification Preparatory work
- · Quality & Safety audits (HSE)
- · Setting up NDT labs
- · Welding procedures & Welders' review / approval
- Vendors assessment & development
- Developing QA / QC systems
- Setting up internal quality systems
- Procedures as per ASME and EN ISO 9712
   Work Instructions & Company written practice
- SHUTDOWN INSPECTIONS
- Qualified Inspector for Shutdown Inspections (API / AWS / CSWIP / ISO / ASNT / PCN)

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- Pumps & Valves, Equipment of nuclear projects
- Drone Inspection Services powered by Volar Altra:
   Ultrasonic Thickness Gauging
   Confined Spaces Inspections

"It is good to have Education, It is Better to have Experience, but it is essential to have Training!"



FUJIFILM DIGITAL RADIOGRAPHY

# DYNAMD

SYSTEM

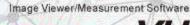






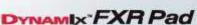














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Email: ndtindia@fujifilm.com | Web: www.fujifilm.in



### Training and Technical Solution Services



TWI India Pvt. Ltd. is a subsidiary company of TWI Ltd. (TWI), a world-leading research and technology organization. TWI provides impartial technical support in Welding, Joining, Materials Science, Structural Integrity, NDT, Surfacing and Packaging. Services include Generic Research, Confidential R&D, Technical Information, Technology Transfer, Training, and Qualification.

As the world's largest training organisation in Welding, Welding Inspection and Non-Destructive Testing, each year over 20,000 participants in more than 60 countries benefit from our expertise. Our courses and examinations are designed to service all key industry sectors, including Oil and Gas, Aerospace, Construction, Power and Automotive, with all courses supported by internationally recognised certification.

In India, other than delivering Training and Examinations towards internationally recognized certification in Welding, Painting, Non-Destructive Testing and Plant Inspection, we offer Bespoke Training Solutions both for industrial member and non-member organizations.

### **Our Training Programmes**

### CSWIP Welding Inspection

- Visual Welding Inspector Level 1
- Welding Inspector Level 2
- Senior Welding Inspector Level 3
- Welding Quality Control Coordinator

### **BGAS-CSWIP Painting and Coatings Inspection**

- Painting Inspector Grade 2
- Painting Inspector Grade 1
- Site Coating Inspector
- CSWIP Cathodic Protection

### CSWIP Conventional NDT Level 1/2/3

- Liquid Penetrant Testing (PT)
- Magnetic Particle Testing (MT)
- Ultrasonic Testing (UT)
- Radiographic Interpretation (RI)
- Eddy Current Testing (ECT)
- Visual Testing (VT)

### CSWIP Advanced NDT Level 1/2/3

- Phased Array Ultrasonic Testing (PAUT)
- Time of Flight Diffraction (ToFD)
- Automated Ultrasonic Testing (AUT)

### CSWIP Plant Inspection

Plant Inspector e-Learing Course

### Other Courses

- Welding Qualification standard ASME Sec IX for Shop Engineers
- Essentials of ASME Section VIII Division 1
- Essentials of Indian Boiler Regulations
- Welder Training & Qualification
- Plastics Welder Training and Qualification
- Fitness for Service (FFS)
- Risk Based Inspection (RBI)



# **Successfully Installed and Commissioned Systems**





### Steel Authority India Limited – Durgapur Steel Plant

**Application:** Testing of the below wheels presently being produced by Durgapur Steel Plant :

- LHB
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- BG LOCO WHEEL
- EMU WHEEL ALT 3
- KOLKATA Metro WHEEL
- MG LOCO WHEEL
- NTPC BOBR WHEEL
- S-PROFILE WHEEL
- WAG9 SF WHEEL
- WAP5 LOCO WHEEL
- WDG4 LOCO WHEEL

The First ever Made In India RDSO approved Ultrasonic Railway Wheel Inspection system by NDTT Technology.



### 2. Indian Oil Corporation Limited

**Application:** 6 Axes and 16 Channel Immersion Ultrasonic Testing System for the inspection of a half-cut pipe 12" to 18" dia., 500 – 1500 mm long pipe sample for corrosion mapping.



### 3. Gas Turbine Research Centre

Application: 7-Axis Immersion C-scan ultrasonic system to enable detection of sub-surface and internal defects using Ultrasonic Testing method for inspection of critical engine disks, shafts and Casings developed for Damage Tolerant Design project.



### 4. TACO Punch Powertrain

Application: Ultrasonic Testing System for Laser Gear Welding parts (Differential Packaging Assembly)



# 5. CSIR-National Metallurgical Laboratory

Application: Motorized 4-Axes (X,Y,Z,Θ) Ultrasonic Immersion Scanning System.





### **QSA GLOBAL**





### **Ultrasonic**

- Ultrasonic Flaw Detector
- Thickness Gauges
- Probes







# **Magnetic Particle**

- Prod Units
- Yokes
- Bench Units
- Ultraviolet Black Light
- Consumables & Essentials







# Radiography

- Gamma Ray Projectors
- IR-192, Se-75, Co-60 Sources
- Radiation Contamination Monitor
- Radiation Survey Meter







# **Ultrasonic Systems**

- On Line / Off Line Systems
- Bar Testing
- Pipe Testing
- Piston Testing
- Component Testing







# **Eddy Current**

- Material testing & Sorting
- Crack Detection
- Conductivity Measurement
- Magnetics Measurement







# **Hardness Testing**

- Portable Solutions
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- Probes
- Blocks







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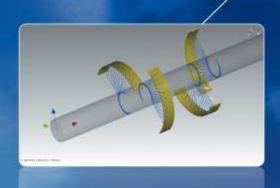
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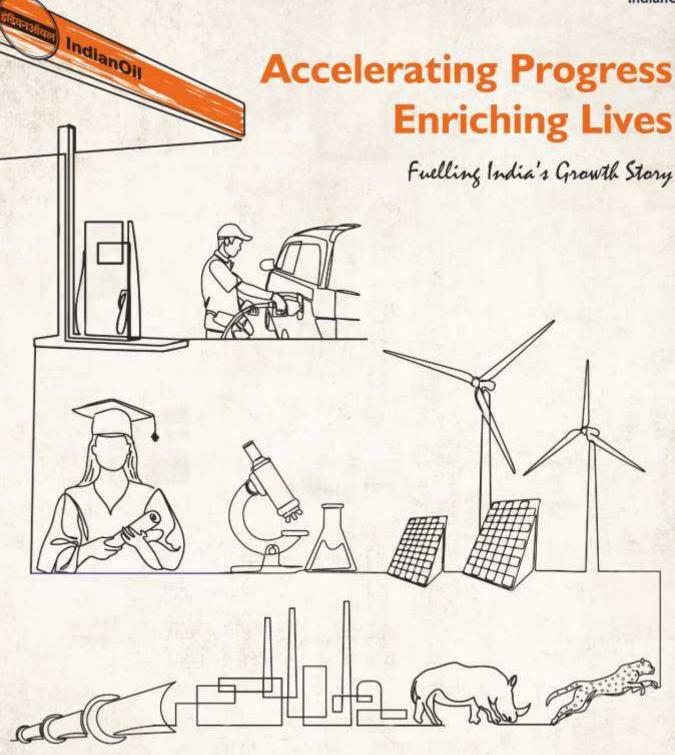
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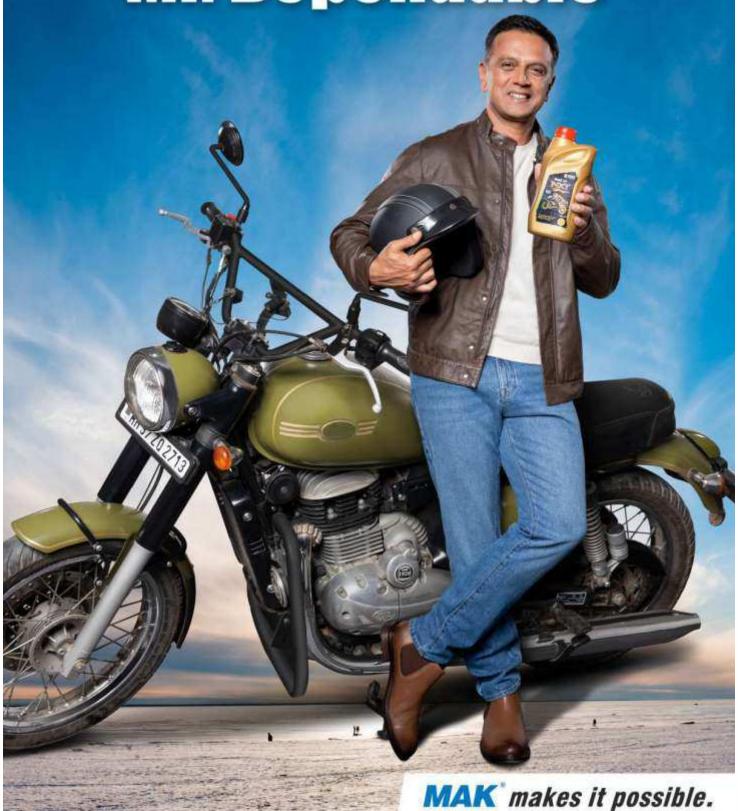
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   Fuel over 2300 flights.
- Our pipelines network transports 133 thousand metric tonnes (TMT) of crude oil and 93 TMT of products.
- 16 thousand tank trucks travel almost 15 lakh km to deliver our products.
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# — Aapki Gaadi Ka— Mr. Dependable



# Ensuring continuous production & maximizing asset uptime across industries



For the last three decades NESL has been making plants across India run more efficiently by minimizing their downtime with versatile range of services which include Online leak sealing, Online Safety Valve Testing, Belzona\* Composites & Coatings, Metal Stitching, Fleetfusion welding and Onsite Machining.

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# Dare to see inside



During the complex manufacturing process of castings, various defects can occur that are not only on the surface. Inside, they can sometimes have a major impact on the stability of the part. However, incorrect geometries also make casted parts useless for later assembly. This is why it is important to detect defects reliably and early enough. This is possible thanks to X-ray technology — with only one scan!

# Possible defects inside or on the surface

### Shrinkage holes

Shrinkage holes are sharp-edged, gas-empty cavities that are often connected to each other. The reasons for this are e.g., too low holding pressure or suboptimal position of the gate.



### Flashes

Hashes are thin metal foils on the casting, caused for example by a too high gate velocity or an incorrectly adjusted clamping.



### Incomplete filling

This defect describes areas of the casting that are not or not completely filled in, or whose contours are not clearly reproduced, for example due to insufficient plunger speed or insufficient holding pressure.



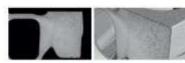
#### P ....

Contaminations and an excessively high gate velocity cars, for example, be reasons for the development of crack structures or thermal fatigue.



#### Pores & porosity

Pores describe spherical gas inclusions which are caused by the gasification of e.g. release agents or due to inadequate die venting.



### Joint & cold shot

This defect describes lines or grooves which are caused by a too low molding or melting temperature, sometimes also by a too long mold filling time.



### Sand or salt residuals

Often moulding sand or salt remains inside the casting after decoring. With X-ray, this becomes visible and the part can be cleaned and then further processed.





#### Inclusions

Inclusions are material components that are usually harder than the base material. They are caused, for example, by contaminated casting material.





#### Spongy areas

Springy areas are accumulations of small pores or shrinkage holes which can severely impair the stability of the casting.





### Blisters

The reason for bulging in the form of blisters on the casting surface is, for example, too high a casting temperature or plunger speed in the second phase.





### Broken core

The breakage or disintegration of a core can be caused e.g. by non-optimal mold material composition or excessive thermal stress on the casting material. This changes the structure of the mold, so that the casted part has incorrect geometries.



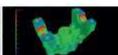


# Possible defects in terms of geometric deviations

### Deformations

Particularly in the case of long, heavy castings, deformation may occur during further transport, if the material has not yet completely cooled down. These deformations become visible in a target/actual comparison, for example.





### Displaced sand or salt core

If matakes are made when positioning the core in the mold before casting, the geometries of the casting no longer match the CAD model. The component is, thus, no longer usable for assemble.





### **EXERTUS CIRCA 80**



Se-75 Close Proximity Projector

# **EXERTUS DUAL 120**



Ir-192 & Se-75 Compatible Projector

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SILFLEX SHIELDING MATERIAL





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Cobalt-60

Selenium-75

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Iridium-192/Se-75 Projector

### **SPEC-300**



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# MAGNAFIEL



### **ABOUT US**

MAGNAFIELD ELECTRONICS AND ENGINEERING PRIVATE LIMITED, LOCATED IN NAVI MUMBAI, PROUDLY SUPPORTS THE "MAKE IN INDIA" INITIATIVE. SINCE OUR FOUNDING IN 2013, WE HAVE BEEN A LEADING SUPPLIER OF NON-DESTRUCTIVE TESTING (NDT) PRODUCTS AND ACCESSORIES, SERVING CLIENTS BOTH IN INDIA AND WORLDWIDE. OUR COMMITMENT TO QUALITY IS REFLECTED IN OUR WIDE RANGE OF PRODUCTS. INCLUDING ULTRAVIOLET LAMPS, RADIOGRAPHIC TESTING EQUIPMENT, MAGNETIC PARTICLE TESTING EQUIPMENT, HARDNESS TESTING EQUIPMENT, ULTRASONIC TESTING EQUIPMENT, NDT ACCESSORIES, AND PRE & POST WELD HEAT TREATMENT EQUIPMENT.

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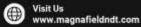


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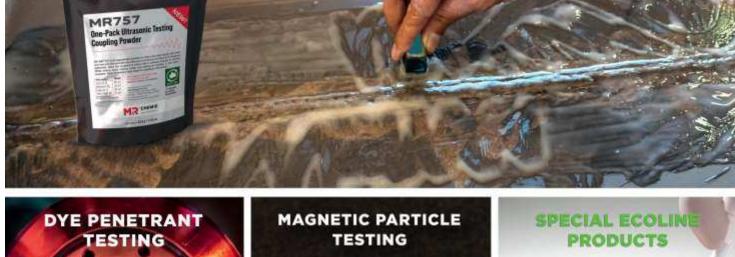
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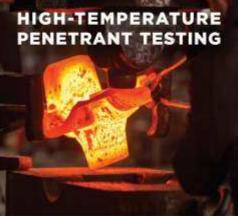
















# **ONLINE SUBMERSIBLE** PLANYS INSPECTION SOLUTIONS









## **Digital Analytics** Reporting



### STORAGE TANK

Shell & Bottom Plate Inspection Corrosion Monitoring Roof Internal & Silt Assessment











# SUMP/BASIN/RESERVOIR

Internal wall / Bottom Inspection Concrete NDT of Walls Silt Assessment

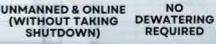






### PORT/TERMINAL

Jetty Piles Visual Thickness (Steel) & Concrete NDT Earth Retaining Structure







# DIGITAL REPORTING

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# Online Inspection of Storage Tank

Planys ROV was deployed to inspect the tank in online conditions (without de-watering) to pro-actively plan for the upcoming shutdown.

Defects identified were categorised by severity (moderate/minor) & along with UT measurements were geo-tagged on the tank drawing visible through the Planys Analytics Dashboard (PAD).









Since commissioning, inspection was not performed due to lack of shutdown (pumps running 24x7). Unmanned ROV inspection was preferred due to confined region, safer option & limited operational window. 25+ defects were identified along with construction debris that could choke the pumps



# Case Study Underwater NDT of Jetty Piles





Jetty piles had corrosion protection insulation and it was not desired to remove the same for corrosion mapping.

Planys deployed a sophisticated underwater NDT method to assess corrosion in the piles without exposing the bare surface thus eliminating the need for cleaning of marine growth.







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- AR MODEL GENERATION
- DIMENSIONAL MEASUREMENT OF TANK

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INSPECTION DATA MANAGEMENT SYSTEM OF PLANT ASSET RISK BASED INSPECTION

#### ROBOTICS

➤ WATER WALL THICKNESS MAPPING USING ULTRA-BOT ROVER REMOTE VISUAL INSPECTION USING CRAWLER

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Lab Address. IRC Engineering Services India Private Limited

Contact Person: Mr. Abhinav Singhi -Director

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- LED Film Viewer & Densitometer
- Eddy Current Sorter
- ATVISION Series of RVI Products

# Distribution of NDT Solutions

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- PAUT/TOFD equipment
- Eddy Current Testing Solutions
- Wire Rope Tester
- Radiation Resistant Cameras
- Magnetic Flux Leakage (MFL) Solutions
- Digital Radiography Solutions
- NDT Simulation Software CIVA

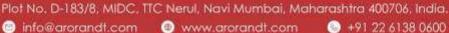


# **Automated NDT Systems**

- Magnetic Particle Inspection Systems for Long Products, Automotive Components etc.
- Ultrasonic Systems for Plates, Coils, Bars, Billets, Pipes, Rails, Railway Wheels etc.
- Eddy Current Systems for Tubes, Bar, Wires, Hard Spots, Automotive Components etc.
- Magnetic Flux Leakage Testing Systems for Black & Bright Bars or Seamless Tubes,
- Immersion Ultrasonic Scanners

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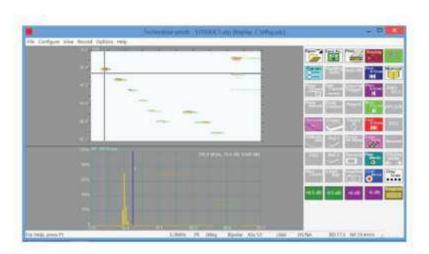
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- √ Long Range Ultrasonic (LRUT)
- √ Remote Visual Inspection (RVI)
- √ Magnetic Flux Leakage (MFL)
- ✓ Alternating Current Field Measurement
- √ Eddy Current (ECT)
- √ Computed Radiography (CR)
- √ Acoustic Emission (AE)
- ✓ Pulsed Eddy Current (PECT)
- √ Industrial CT

















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We have evolved over the years by integrating our offerings into a range of performance improvement products & services that help our industry clients solve a range of maintenance issues and save enormous costs over the course of operation.

We offer the following NDT Inspection services to various industries.

- ECT/RFT/NFT/MFL/IRIS & APR Method Inspection for Heat Exchanger & Condenser Tubes.
- Helium Leak Testing for Power Plant Condenser Vacuum system & Hydrogen Generator, Heat Exchanger tubes leak tests etc.,
- 3. Phased Array Ultrasonic Testing & ToFD Method Inspection for Weld Joints.
- 4. Acoustic Emission Testing for storage tank & vessels.
- 5. In-situ Oxide Scale measurement, Borescope, Metallography, Thickness Survey.
- Critical Components Failure Root Cause Analysis.
- 7. NDT inspection for condition assessment of Boiler, Turbine, vessels & pipelines.

Other Industrial Services provided are Chemical Cleaning, Steam Blowing, Foam Cleaning, Oil Flushing, Bullet Cleaning, Hydro Jet Cleaning, Dry Ice Cleaning & Dry Powder Cleaning, Heat Exchanger & Condenser Tube Replacement Service, Valve Repair & Test, FGD / Chimney / Tank / Pumps & Impeller / Silo / Bunker & Flooring Coating, Condenser / Heat Exchanger Protective Coating

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#### Contact Persons:

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Mr. J.Ramajayam- Asst Manager (NDT - Inspection)- +91 9445828209

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- Automated Reformer Tube Inspection system (ARTIS)
- Leak Testing (Helium, Vacuum Box, Air Borne)
- In-situ Metallography & Hardness measurement
- Robotic Inspection of Tanks, Pressure Vessels & Boiler Tubes
- LRUT, SRUT, Acoustic Emission Test, MFL, PECT, EMAT
- Composite inspection by Matrix Array UT (MAUT)
- Customized NDT Trainings

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- Fitness For Service
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- Reformer Tube Inspection
- Risk Based Inspection
- Remaining Life Assessment

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- Corrosion Studies
- Material Testing
- Indigenization

#### Accreditation

- NABL Accredited for chemical, mechanical, NDT
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- CBB approved TCR Advanced as a "Well-known Remnant life Assessment Organization" and "Well-known Material Testing Laboratory.



Evolve by TCR Advanced Engineering Pvt. Ltd. is a training institute in Vadodara primarily for Asset EVOLVE by Integrity Management. With trainings like Non-Destructive Testing, Damage Mechanisms in Industries and Basics of Metallurgy, evolve wants their candidates to enhance their perception towards prevention of failure and also solve failures by analysing the root cause.

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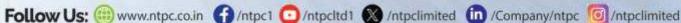
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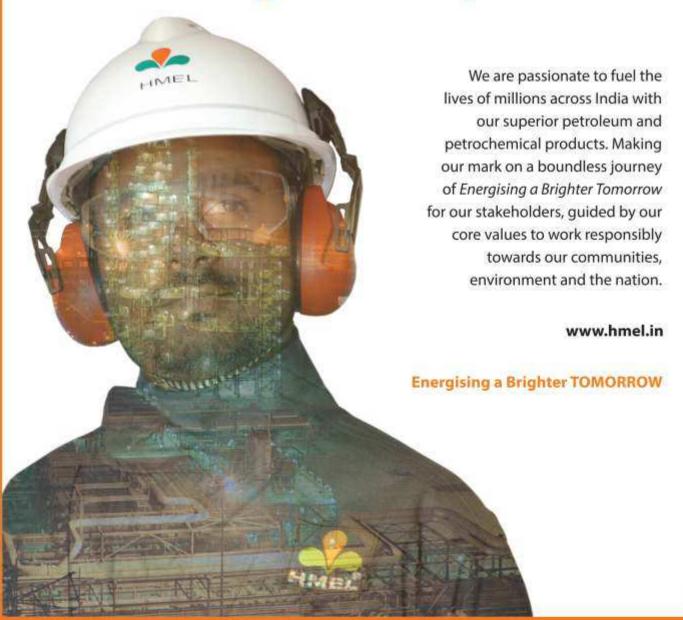








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# Absolute information

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- Shear modulus
- Poisson's ratio
- Internal friction

#### Impulse Excitation Test (IET)

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#### Relative information

- Fault detection
- Quality assurance
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For over 15 years, Vibrant NDT Services has been at the forefront of NDT technology, delivering advanced solutions that ensure safety, quality, and efficiency across various sectors, including aerospace, Automobiles, energy, oil& gas, infrastructure, and manufacturing. Our dedication to innovation and customer-centric approaches has established us as a trusted partner in achieving reliable and precise results.

Ultrasonic Testing (UT)

Oxside scale thickness measurement

Magnetic Particle Testing (MT)

Liquid Penetrant Testing (PT)

Tubes Inspection: ECT, RFET, IRIS, MFL.

Helium Leak Testing (HLT)

Phased Array Ultrasonic (PAUT &TOFD)

Long Range Ultrasonic Testing (LRUT)

Acoustic Pulse Reflectometry Inspection System (APRIS)

Boroscopy inspection

Infrared thermography

Hardness testing

Radiography testing

Positive material identification

Pulsed eddy current testing

Traning & Certification

Magnetic Particle Inspection Equipment (Prod Type, Bench (head & coil)

Eddy Current testing (Manual, Semi-Automatic, fully automatic system)

Fluorescent Penetrant Testing system

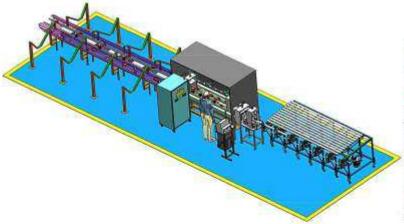
Ultrasonic bar, tube, plate Inspection system

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# PEAKNOT

# WHO ARE WE?

Peak NDT is a high end technology company specialising in the development, production and support of multichannel and phased array ultrasound controllers for use in the Non-Destructive Testing industries. With our particular expertise in ultrasonics, we also provides consultancy services, including feasibility studies, technique development and ultrasonic inspection modelling.



# OUR PRODUCT RANGE

At Peak NDT, we offer a range of high-performance ultrasonic instruments designed to meet the needs of the most demanding industries. Here's a quick overview of what we offer:

# MICROPULSE LTPA 64/128



The LTPA 64/128 provides a high performance, flexible and compact ultrasonic inspection system. All LTPA's are completely enclosed units, capable of conventional, Phased Array and PWI/FMC acquisition processes and, uses Power over Ethernet technology and Gigabit Ethernet for fast data transfer.

# MICROPULSE LTPA 64/128-10GB



The LTPA 64/128 – 10Gb is a high speed data transfer version of the standard LTPA instrument. With a 10Gb Ethernet interface the instrument seriously speeds up your inspections where data transfer rates are a limitation, such as FMC. This instrument retains the compact rugged, lightweight and enclosed unit. Additionally the 10Gb unit has 4 conventional channels (pulse echo or pitch-catch) available.

# MICROPULSE MPLT



The MPLT is a compact multi-channel conventional ultrasonic instrument in an enclosed unit (no fans). Using PoE technology, with extended dynamic range modes, parallel firing capability and up to 48 conventional channels with 300V pulser capability in its standard enclosure, it is ideally suited for your multi-probe pulse-echo and TOFD inspections requirements.

# MICROPULSE 6PA



The standard MicroPulse 6 is a 128/256 phased array system, that also provides 12 separate high-performance 300V conventional channels. Providing an extremely capable and flexible instrument. MicroPulse 6 is an enclosed unit with no external air intakes, and is capable of conventional, phased array and PWI/FMC acquisition processes.

## MICROPULSE LT2



The LT2 is a complete package with a small footprint, and Power over Ethernet technology, enabling instrument positioning close to the inspection and also includes extended dynamic range modes. The LT2 is ideally suited for machine mounted/robotic inspections.

From advanced Phased Array Ultrasonic Testing systems to high-performance Ultrasonic Testing solutions, Peak NDT products are designed to meet the toughest inspection challenges across industries like aerospace, oil & gas, manufacturing, and power generation. Our technology helps you optimise inspection processes, ensuring safety, reliability, and efficiency, while keeping you ahead of industry demands.

All our instruments are an open architecture, with direct access to the control of the instrument and the data acquisition, so you can build a user interface to meet your specific requirements. Highly capable off the shelf software solutions are available for our products from Utex Scientifics (NDT Suite) and TWI Crystal.

#### WEB

# SIGMA NDT GROUP

# Specialized Advanced NDT & Heat Treatment Service Provider

SIGMA NDT GROUP has been established in the year 1997 in Chennai with Non Destructive Testing and Certification for different industries in India. The Company's highly experienced team with their technical experience and their commitment towards quality and timely completion of tasks. The company has a wide range of advanced NDT Techniques and expects to undertake any challenging jobs.

SIGMA NDT GROUP is certified in Quality & Management Systems in ISO 9001: 2015

Our Specialization: PAUT, AUT, TFM/PCI (3D imaging with Total focusing method), PAUT at high temperatures, MFL, Specialized Heat treatment Services.

Our offices are in Chennai, Mumbai, Jamnagar, Kolkata

Contact Numbers:

R. K. Dey +91 99798 95022

S. K. Dey +91 91763 35555



# A New Approach To NDT...



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# PHASEYE FMC-64

The new generation of FMC and TFM
Ultrasonic Phased Array Flaw Detector

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see all, see more.





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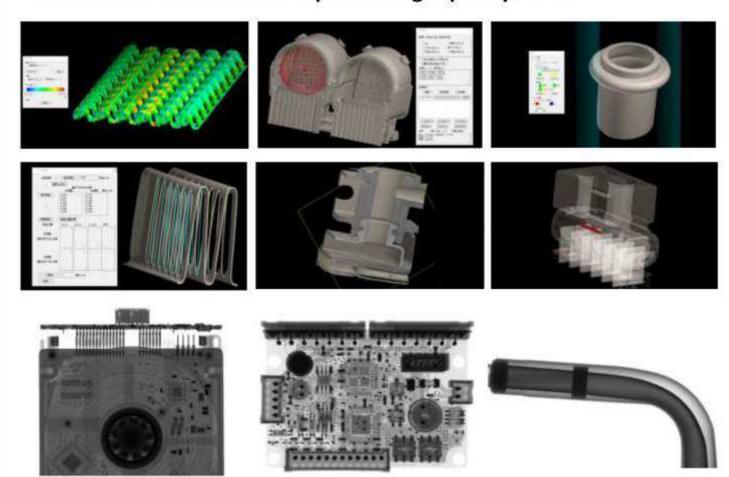




# Micro Focus X-ray CT Scanner X-CROSS



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- Customize for each customer demands
- Utilize the reverse engineering for future manufacturing systems
- Manufacture in India with Japanese high quality basis



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92-1 Matsuba, Takaoka, Toyota, Aichi, 473-0933, Japan http://www.comco.com/

# **NOVSOL COMCO INDIA PVT LTD**

NO.445/1 (305/1), 6th FLR, GUNA COMPLEX, ANNA SALAI, Teynampet, Chennai, Chennai-600018, Tamil Nadu, India



# INTERNATIONAL RELIABILITY SERVICES

Your Trusted Partner in NDT and Inspection Solutions









### **ABOUT US**

Founded in 2000, IRS is a ANAB-accredited inspection body providing inspection and non-destructive testing (NDT) services for industries such as fabrication, construction, marine, and oil & gas. Services include conventional and advanced NDT, quality assurance and control inspection, NDT training, and consultancy.

# **OUR SERVICES**

#### CONVENTIONAL NDT SERVICES

- Magnetic Particle Testing (MT)
- · Liquid Penetrant Testing (PT)
- Radiography Testing (RT)
- Ultrasonic Testing (UT)
- Positive Material Identification (PMI)
- Visual Testing (VT)
- Eddy Current Testing (ECT)
- Ferrite Testing (FT)
- Hardness Testing (HT)

#### **HEAT TREATMENT SERVICES**

- · Pre-Heat Treatment
- · Post Weld Heat Treatment (PWHT)

# ROPE ACCESS SERVICES

- · Rope Access Inspection
- · Rope Access Maintenance and Repair

## ROBOTIC INSPECTION SOLUTIONS

- · Remote Visual Inspection
- Internal UAS Drone Inspection
- · External UAS Drone Inspection

#### MECHANICAL SERVICES

- Flange Management Services:
  - Bolt Torquing
  - Bolt Tensioning
  - \* Flange Face Machining
- · Tube Cleaning
- Cold Cutting

#### TRAINING AND CERTIFICATIONS

- . Conventional NDT Level I & II
- Advanced NDT Level I & II
- · Basic Radiation Safety





# ADVANCED NDT SERVICES

- Phased Array Ultrasonic Testing (PAUT)
  - · Weldment Inspection
  - Corrosion Mapping Services
  - · Flange Face Corrosion Monitoring
- · Time of Flight Diffraction Ultrasonic Testing (ToFD)
- · Long-Range Ultrasonic Testing (LRUT)
- Short Range Ultrasonic Testing (SRUT)
- · Pulsed Eddy Current Testing (PECT)
- · Alternate Current Field Measurement (ACFM)
- Magnetic Flux Leakage Inspection (MFL)
- · Tube Testing Services:
  - Eddy Current Testing (ECT)
  - Eddy Current Array Testing (ECA)
  - · Remote Field Testing (RFT)
  - · Near Field Testing (NFT)
  - Near Field Array (NFA)
  - · Internal Rotary Inspection System (IRIS)
  - Magnetic Flux Leakage Tube Testing (MFL)
- Digital Radiography (DR)
- Open Vision Real Time Radiography (RTR)
- Infrared Thermography (IR)
- · 3D Laser Scanning
- Magnetic Rope Testing (MRT) for Wire Ropes
- Acoustic Emission Testing (AET)
- Holiday Testing
- Ground Penetrating Radar (GPR)

#### OTHER SERVICES

- Quality Assurance/ Quality Control Services
- NORM Survey
- NDT Level III Consultancy
- Welding Data Logger
- Manpower Supply
- Plot no 4, 1st Street, Bharathi nagar main road, Bharathi nagar, Perungalathur, Chennai, Tamil Nadu – India 600063
- ( +91-9442220451
- info@irs-inspection.com
- www.irs-inspection.com.bn





# ABOUT US

# Aerica Engineering Pvt Ltd: Delivering Innovative NDT Solutions

Established in 2014, Aerica Engineering Pvt Ltd is a dynamic company dedicated to manufacturing, customizing, and supplying cutting-edge products for Non-Destructive Testing (NDT). As an ISO 9001:2015 certified organization, we uphold the highest standards of quality and excellence.

#### Our Commitment:

Unique and Advanced Products: We specialize in creating unique and advanced NDT solutions that address industry-specific challenges. Our products are designed to enhance inspection processes, improve efficiency, and ensure safety.

#### **Customized Solutions:**

At AEPL, we understand that every client's needs are different. Our team of highly experienced and trained professionals collaborates closely with clients to provide tailored solutions that meet their specific requirements.

# INNOVATIVE & HIGH-QUALITY PRODUCTS

"Offering innovative products makes serving our clients simple. We offer quality products at a competitive cost. Our products are second to none when it comes to usability and durability"

# OUR PRODUCTS







BORESCOPE



NDT QUALITY TESTER

We are India's leading manufacturer, exporter, supplier and service provider of a wide range of equipments, machinery, tools and latest engineering solutions including

- Drain & Pipe Inspection camera system
- Crawler Inspection Camera
- · Borescopes / Videoscope
- Ultrasonic Thickness Gauge
- Coating Thickness Gauge
- Hardness Testers

- Ultrasonic Flaw detector
- Underwater CCTV Camera
- · Eddy Current Flaw detector
- Wire Rope Inspection System
- Deep Well Inspection Camera
- Handhald XRF Metal Analyzer

# OUR CLIENTS











# **CONNECT WITH US**



+91 77770 25308 / 022 31151510



206, Shree Krishna Industrial Estate, Ketkipada, WesternExp. Highway, Dahisar East, Mumbai - 400 068







# ADVANCED ULTRASONIC TESTING SPECIALIST SINCE 2005

# Inspection Through Innovation and Technology



# WHO ARE WE?

**U-SONIX Inspection Solutions Pvt Ltd**, an ISO 9001:2015 certified leader in Non-Destructive Testing (NDT) ensures the structural integrity of your assets with precision and reliability.

# Our Services:

- PAUT: Advanced inspection for complex structures.
- TOFD: Accurate weld defect detection.
- Corrosion Mapping: In-depth failure prevention analysis.
- Auto UT: Precision through automated testing.

# Why Choose Us?

- TRUSTED BY INDUSTRY LEADERS: ONGC, DNV, NTPC, GE, SHELL, NPCIL, SIEMENS,
   VESTAS, VEDANTA, TATA POWER, RELIANCE INDUSTRIES LIMITED, L&T AND MORE.
- Quality guaranteed with global accreditations and top-tier partnerships.













# U-SONIX INSPECTION SOLUTIONS PVT LTD

No. 2A/2 Annai Complex, Rajendran Nagar, Club Road, East Tambaram, Chennai - 600 059
U-SONIX INTERNATIONAL LIMITED

Office No.416, Burlington Tower, Business Bay, Dubai, United Arab Emirates Ph:+91 98407 86687 / +91 63839 92501 admin@u-sonix.com / www.u-sonix.com

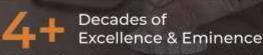


夏山

Visual

Upgradation Services





- Advanced NDT (PAUT, TOFD & LINAC)
- Gamma Radiography (Using X-Ray, Co - 60, Ir - 192 & Se - 75) - Casting Upgradation
- Ultrasonic Inspection & Thickness
- Magnetic Particle and Dye Penetrant Inspection
- Hardness and PMI



Penetrant Testing



### Corporate Office

- No. 5), 3rd Floor, 5th Main, 36th Cross, Jayanagar 5th Block, Bengaluru - 560 041, India
- · 91 80 2653 1007
- info@sitasndt.com

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- shimoga@sitasndt.com

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- C +91 960 602 8192
- sangli@sitasndt.com

### Abu Dhabi

### Sitas Technical Services LLC

- PO Box 43465, 405 B Wing, Al Saman Tower, Hamdan Street Abudhabi, UAE
- C +971 02 6333035
- abudhabi@sitasndt.com

















### **ALL TESTING UNDER ONE ROOF**

NABL Accredited Laboratory as per ISO/IEC 17025-2017

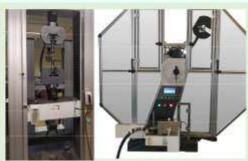


### CHEMICAL TESTING

(OES/ICP OES/ XRF /EDX)

- Iron Base
  - o Carbon Steel
  - o Low Alloy steel
  - Stainless Steel
  - o Duplex
  - o Tool steel
  - o Ni-Resist
  - Cast Iron/SG
  - o Free Cutting Steel
- Aluminum Base
- Nickel Base
- Copper Base
- Cobalt Base
- Titanium Base
- Zinc Base
- Lead Base





### MECHANICAL TESTING

- Tensile Testing
- Impact Testing
  - o High Energy (up to500J)
- · Bend Test
- · Compression Test
- Hardness
  - Rockwell
  - o Brinell
- Vickers
- WPS/PQR Qualifications
  - o ASME
  - o AWS
  - o EN/IS
- Fasteners Test
- Flattening Test
- Weld Qualification

### METALLURGICAL TESTING

- Microstructure Evaluation
- Determination of Heat Treatment
- Graphite size, distribution
- Effective Case Depth
- Decarburization
- Nitriding depth
- Macro-examination
- Inclusion rating
- Coating thickness Measurement
- Platingthickness
- Porosity
- WeldEvaluation
- Grain Flow and GrainSize
- Ferrite Counts, Volume Fraction
- Weld Assessment

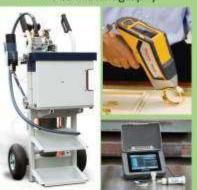


### SPECIAL TESTING

- Failure Analysis
- SEM/EDX
- Cyclic Corrosion
- Xenon Arc
- **UV** Exposure
- **Environmental Testing**
- Fatigue and Fracture Toughness

### **ON-SITE TESTING**

- Portable Spectrometer
- PMI (Positive Metal Identification)
- Ferrite Content (Ferritoscope)
- PortableHardness
- Surface Roughness
- Coating Thickness
- In-situ Metallography



O CHENNAI (H.O)

COIMBATORE COLLECTION CENTER

O HOSUR

O Sriperumbudur O Malur (KA) O Bommasandra (KA) O Narasapura (KA)

### CORROSION

- Intergranular Corrosion Test
- Pitting & Crevice Corrosion Test
- Chloride Stress Corrosion Cracking Test
- Sulphide Stress Corrosion Cracking Test
- Hydrogen Induced Cracking test
- Mercurous Nitrate Test
- Salt Spray NSS, CASS, ASS
- GI Coating Thickness
- Porosity Test





### CHEMICAL WET

- Metals and Alloys
- Gas Analysis ONH
- Ferro Alloys
- Ores and Mineral Products
- **Building Materials**
- Water and Wastewater
- Industrial Effluent (ETP)
- Coal, Coke & Graphite
- Fine Chemicals
- Fertilizers
- Hazardous & Toxic Elements
- Miscellaneous



### PLASTICS

- DSC/TGA Analysis
- Rockwell Hardness
- Melting Point

**ETIR** 

- Moisture Content
- Tensile, Flexural,
- Compression
- Heat Cycle Resistance
- Ash Content
- Heavy Metals/RoHs
- Melt Flow Index
- Taber Abrasion
- Flammability
- Izod/Charpy Impact Heat Deflection
  - Temperature
- Thermal Conductivity
  - UV/Xenon Weathering

### RUBBER

- **Durometer Hardness**
- Specific Gravity/density
- Compression Set
- Ash Content
- Polymer Identification
- Tensile & Elongation
- Accelerated Heat Ageing
- Resistance to ASTM Oil, Water and Fuel
- Tear Strength -Angular /Crescent
- Abrasion Resistance
- Heavy Metal DEHP, BBP, DBP, DIBP, PBB, PBDE, Hg, Pb,Cd Modulus of Elasticity

### Performance Test

### CIVIL (Construction Materials)

- Cement
- Fine Aggregate (Sand)
- Coarse Aggregate
- Bricks, Blocks and Pavers
- Concrete Cube and Core
- Soil Field Density
- Concrete Design Mix
- Steel (TMT Bars)
- WMM, GSB and Bitumen
- NDT RHT, UPVT, HPT



### PAINT TESTING

- Dry Film Thickness
- Wet Film Thickness
- Accerlated Storage Stability
- Residue on Sieve
- Wet Opacity, Volume Solids
- Tubular Impact
- Scratch Hardness
- Fineness of Grind Finish, Flash Point
- Flexibility & Adhesion -

- Color, Consistency
  - Gloss
  - Phtalic Anhydride
  - Pressure Test
  - Resistance to
  - Acid/Heat/Chlorine
  - /Alkaline/Petrol/Oil
  - Lead Content
  - Ash Content
  - Barcol hardness
  - Adhesion Test



### **NDT TESTING**

- Ultrasonic Testing (UT)
- Penetration Test (PT)
- Magnetic Particle Inspection (MPI)
- Visual Inspection (VI)
- Radiography Inspection (RT)
- Holiday Test
- Salt Condamination Test
- Pull off Test (Paint)
- Adhesion Test CLIENTS

















### SECTORS

- Automative
- Heavy Engineering
- Aeronautical
- Reverse Engineering
- Marine
- Oil and Gas
- Defense
- Construction
- Pharma Agriculture
- Boiler
- SPACE Research





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- Throu-paint / coating capability
- A-scan / B-Scan capability





### CarestreamNDT









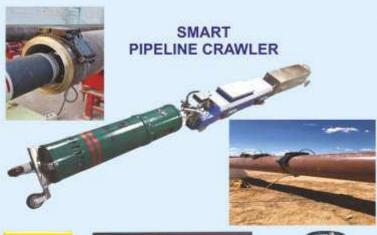
























**RADAX SURVEY METER & ZONE MONITOR** 



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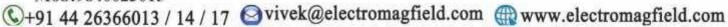
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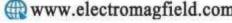


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sales@electromagfield.com

Mob:9840023015







### **TOPAX NDT SOLUTION LLP**

Sales Offices: B 61/114. Veena Ind Premises Society. Near City Midl.Opp. Monginis Cake Factory. Off Andhen Link Road, Andhen (West). Mumbai 400 053. India. Cell: 083568 53922. Emini Id: prab/g/reparadivelution.com. info@isparadivelution.com. www.tsparadivelution.com

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COMPUTED RADIOGRAPHY(CR) =

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### BAM CERTIFIED

### FROST SULLIVAN

BEST PRACTICES AWARD

PRODUCT DIFFERENTIATION AWARD
NEW PRODUCT INNOVATION AWARD







HPX-DR 3543PE

Non Glass , Large Format Detector

Pixel Pitch: 139um



HPX-DR 2530PH

Non-Glass High resolution, Pixel Pitch : 98um



HPX-DE-2530PC

Non-Glass High Speed, Pixel Pitch: 145um



HPX-DR 2329GK

High Resolution, Compact Detector Pixel Pitch: 75um



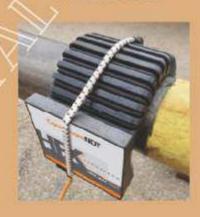
HPX-DR 4336GH

High-Resolution, Large Format Detector Pixel Pitch: 100um

### **CR PHANTOM**



### HPX-ARC 1025PH



BENDABLE DR

### Carrier Plate



Small size & any shape IP

### Duplex IQI



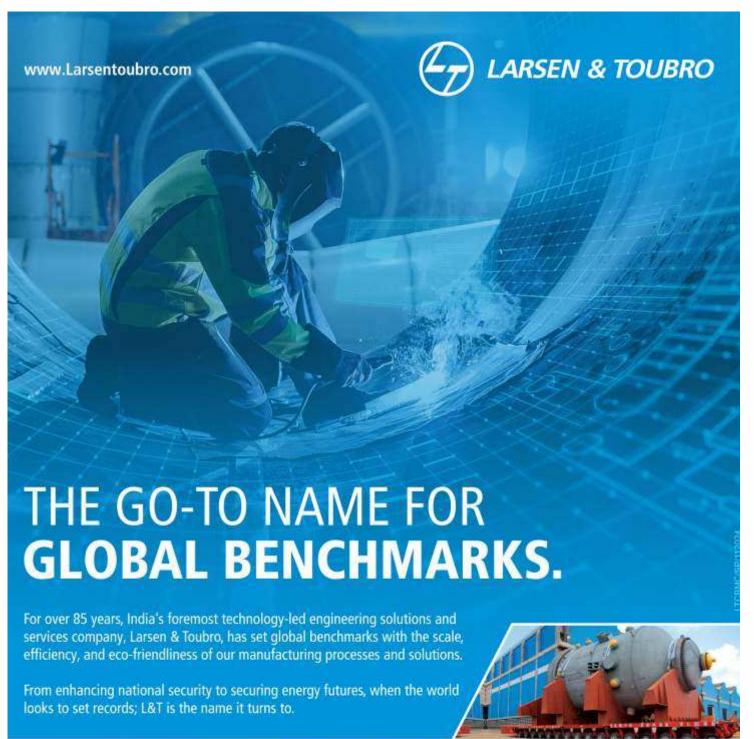
### Film Digitizer Array -2905 HD



### INDUSTREX - IMAGING PLATE



- Customized IP Sizes
- Flexible like film



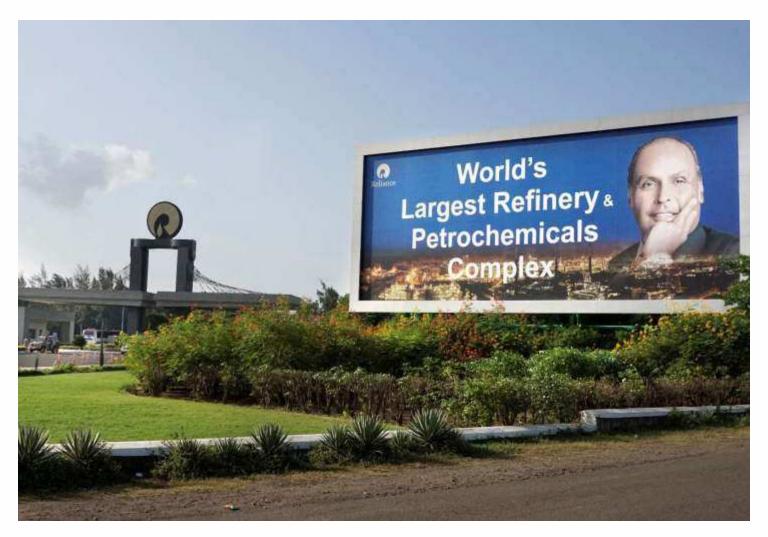




Disclaimer: The business does not manufacture any explosives or ammunition of any kind, including cluster munitions or antipersonnel fandmines or nuclear weapons or components for such munition. The business also does not customise any delivery systems for such munitions.

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