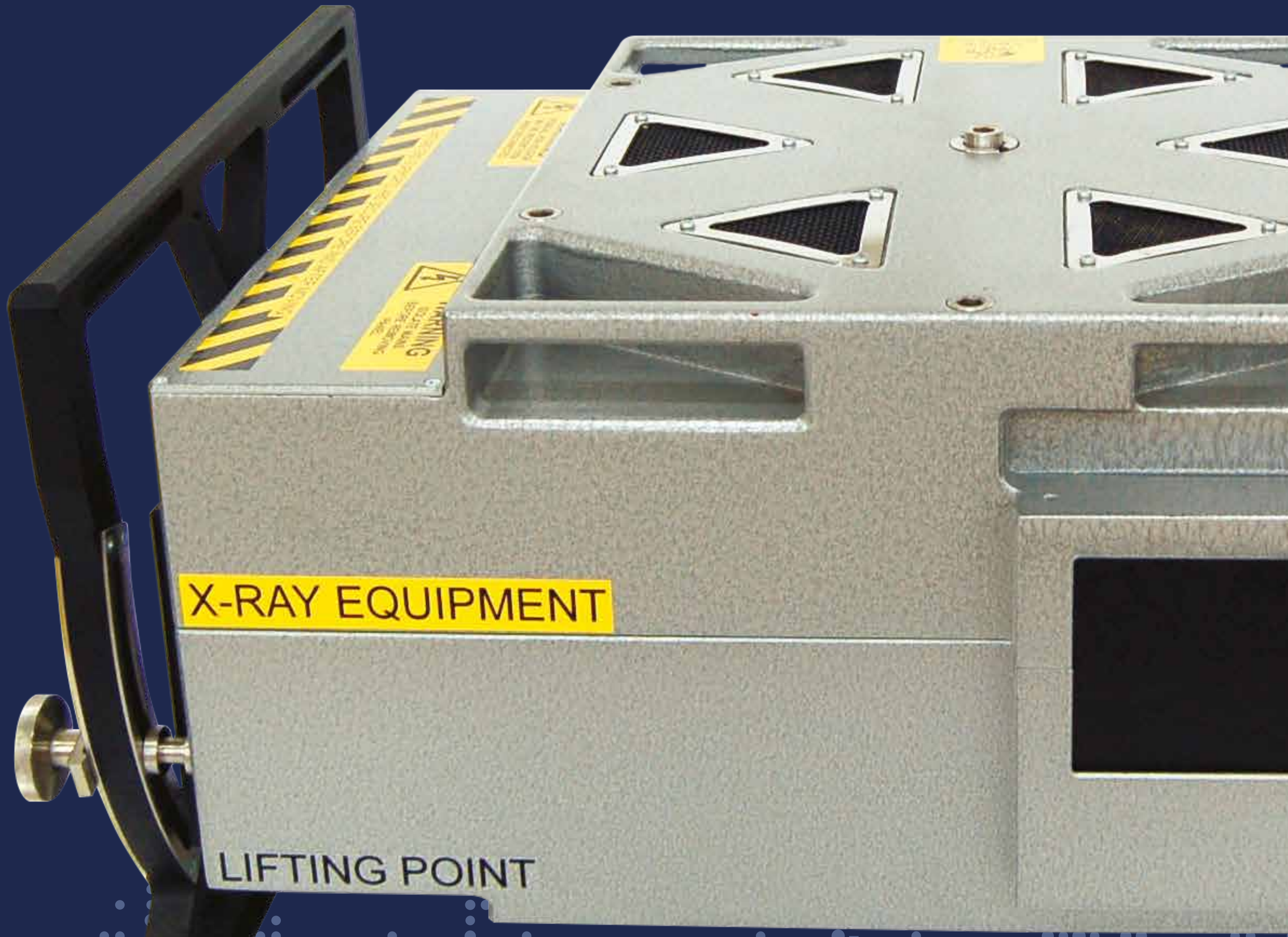
PROUDLY SUPPLYING THE **NDT** INDUSTRY FOR OVER **35 YEARS**

35TH ANNIVERSARY
EST. 1986

PORTABLE X-RAY

BETATRON

CASE STUDIES



JME
ADVANCED INSPECTION SYSTEMS

CONTENTS

JME
ADVANCED INSPECTION SYSTEMS

PXB:2.5

Dose Rate (Min)	0.7	R/Min (@1mtr)
Dose Rate (Average)	1	R/Min (@1mtr)
Energy Range	1 to 2.5	MeV
HVL Steel	20	mm
HVL Concrete	-	mm
Focal Spot	0.2 x 2	mm
Max. Penetration Steel	120	mm
Max. Penetration Concrete	500	mm

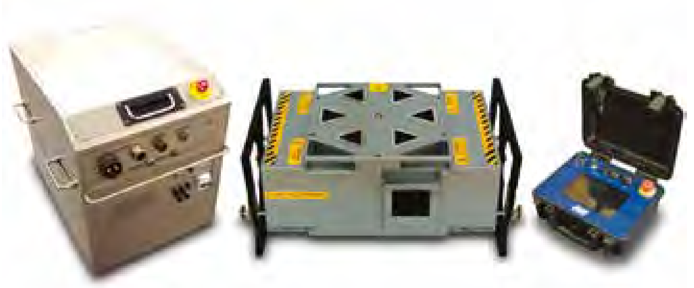
PXB:6

ALSO AVAILABLE WITH
PXB:RF

Dose Rate (Min)	3	R/Min (@1mtr)
Dose Rate (Average)	4	R/Min (@1mtr)
Energy Range	2 to 6	MeV
HVL Steel	28	mm
HVL Concrete	102	mm
Focal Spot	0.3 x 3	mm
Max. Penetration Steel	180	mm
Max. Penetration Concrete	750	mm

PXB:7.5

ALSO AVAILABLE WITH
PXB:RF



Dose Rate (Min)	5	R/Min (@1mtr)
Dose Rate (Average)	7	R/Min (@1mtr)
Energy Range	2 to 7.5	MeV
HVL Steel	32	mm
HVL Concrete	110	mm
Focal Spot	0.3 x 3	mm
Max. Penetration Steel	220	mm
Max. Penetration Concrete	1000	mm

PXB:9

Dose Rate (Min)	15	R/Min (@1mtr)
Dose Rate (Average)	20	R/Min (@1mtr)
Energy Range	2 to 9	MeV
HVL Steel	35	mm
HVL Concrete	125	mm
Focal Spot	0.3 x 3	mm
Max. Penetration Steel	300	mm
Max. Penetration Concrete	1250	mm

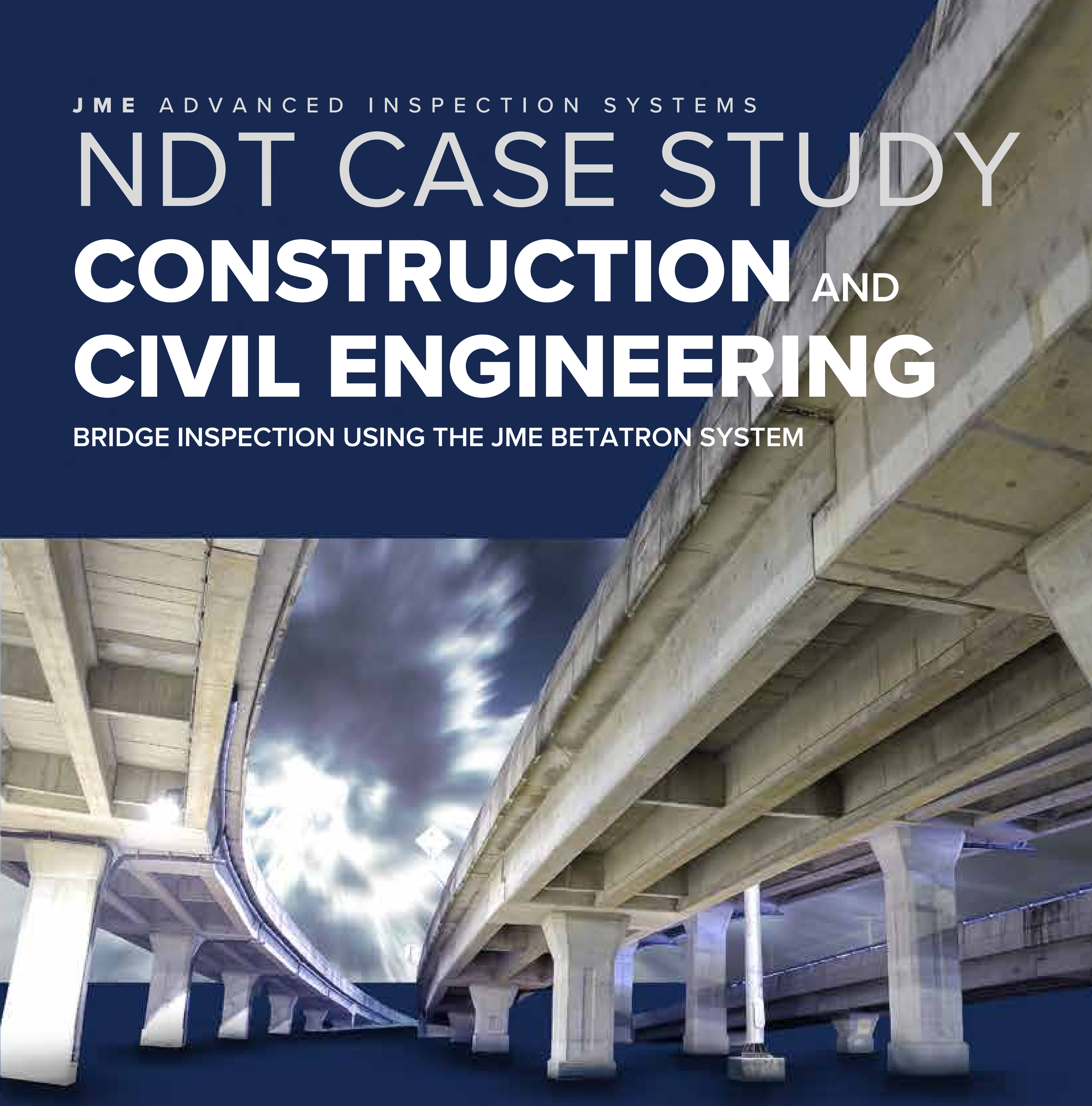
Penetration can be dependant upon type, density of material and image acquisition method. Please contact JME for more information

JME ADVANCED INSPECTION SYSTEMS

NDT CASE STUDY

CONSTRUCTION AND CIVIL ENGINEERING

BRIDGE INSPECTION USING THE JME BETATRON SYSTEM



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X-RAY TUBES ▪ BETATRON PORTABLE X-RAY ▪ X-RAY GENERATORS ▪ TROLLEY SYSTEMS

PORTABLE X-RAY SOLUTIONS

PRODUCT CASE STUDY
Construction and Civil Engineering Inspection

BRIDGE INSPECTION USING THE JME BETATRON SYSTEM

In March 2019, JME were tasked with supporting an inspection company in Italy to perform X-Rays of a road bridge in an area notorious for earthquakes. After the Morandi bridge collapse in Genoa in 2018, large scale discussions took place to determine the extent of the potential problems other structures could face as a result of an increase in pollution, corrosion, vehicle traffic, geological factors and poor maintenance schedules.

The Morandi bridge was a new breed of structure, constructed pretty much solely of pre-stressed concrete, and as a result required substantially less steel cabling than previous structures. This was originally billed as a maintenance free method of construction, and as a result, thousands of bridges, viaducts and tunnels were constructed in a similar manner.

Bringing us forward to the current day, many of these structures are still yet to be inspected 100%, ultimately raising questions as to whether there are going to be repeats of the Morandi bridge collapse.

JME delivered their 7.5 MeV Portable Betatron system to a small village north of Rome, and supported the inspection company, alongside the digital panel supplier in successfully carrying out over 120 individual exposures on concrete thicknesses ranging from 300 – 1100 mm's. Using this system, the inspection company were able to evaluate, not only the presence of the steel cables within the concrete, but take accurate measurements of its thickness, determine its integrity, and ultimately prove whether the structure was safe.

The portability of the Betatron system, coupled with its high energy output puts it in a position of being the only X-Ray source capable of performing this kind of inspection. Using an underbridge inspection platform, the Betatron system and digital panel were mounted in their specially designed fixtures and lowered into position under the bridge superstructure.

The JME 7.5MeV Betatron system comes equipped with a wireless control panel and handset, with an open air range of 3km, meaning exclusion zones present no operational issues as well as an increase in safety for operators.

If you would like more information regarding the JME PXB:7.5, please email sales@jme.co.uk or telephone +44(0)1502 500969

JME ADVANCED INSPECTION SYSTEMS

NDT CASE STUDY

OFFSHORE BETATRON

IN ASSOCIATION WITH
AXESS GROUP

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PORTABLE X-RAY SOLUTIONS

NDT CASE STUDY

BETATRON 7.5MeV IN AN OFFSHORE ENVIRONMENT

PROJECT OVERVIEW

It was identified that part of a heavy wall pipe, in relation to an offshore wellhead, failed/collapsed during a routine drilling operation. Additionally, a drilling tool had become lodged inside the tubing due to a breakage and is stuck in the well.

After initial evaluation, it was decided that the best 'product' solution for the project was through Radiography using the JME High Energy Portable Betatron system (PXB 7.5MeV). This equipment could be used to detect where the pipe had collapsed and confirm the area in which the tool was stuck so it could be removed and the pipes repaired.

REPAIR AND POST REPAIR INSPECTION

The project would include a complex well operation to expand the collapsed pipe and remove the tool that was lodged in the pipe. Once the tool had been removed, additional Radiography with the Betatron system would be required to ensure the repair was successful and operation of the pipelines could continue.

THE SOLUTION

The JME Betatron system was used along with Film Radiography to monitor inside the pipe between the repair operations. Due to the expense associated with downtime on an offshore platform, the customer needed to verify that the operation proceeded and progressed as planned. The plan of operation was to conduct a radiography shot with the Betatron, before, during and after the repair procedure was completed. This ensured that the full scope of the project could be completed as quickly and efficiently as possible with the minimum of disruption.

The inspection measure was simple, before the well could be put into operation, the criteria was to prove if there was a 2" solid steel bar inside the 7" casing. During well operation, radiography was conducted from different angles to ascertain the direction of the collapse in the 7" casing. A final radiograph was taken after well operation to prove that the 2" solid steel bar was removed.

CHALLENGES

The main challenge with this project was radiation protection for the operators, in what was a relatively small, yet open area with lots of machinery present. The requirement was to shield enough of the radiation and keep them at low enough levels to fulfill the requirements of 'radiation protection'. The majority of exposures were done after the main day shift was over, this minimized the amount of people around the exclusion zone and in areas close by. All exposures performed with the Betatron system were done so the emission direction was pointing towards the sea and not in the direction of other rig modules.

The well consists of five casings, dimensions as follows:
32" Pipe - 25.4mm thickness
20" Pipe - 16.1mm thickness
13 3/8" Pipe - 13.1mm thickness
10 ¾" Pipe - 13.8mm thickness
7" Pipe - 10.4mm thickness (production pipe)

The total thickness to be penetrated with the Betatron system was 1576mm, along with the potential of having accumulated water between each pipe wall. The required exposure time was between 25 to 30 minutes with 7.5MeV to achieve the required film sensitivity on AFGA D7 film.

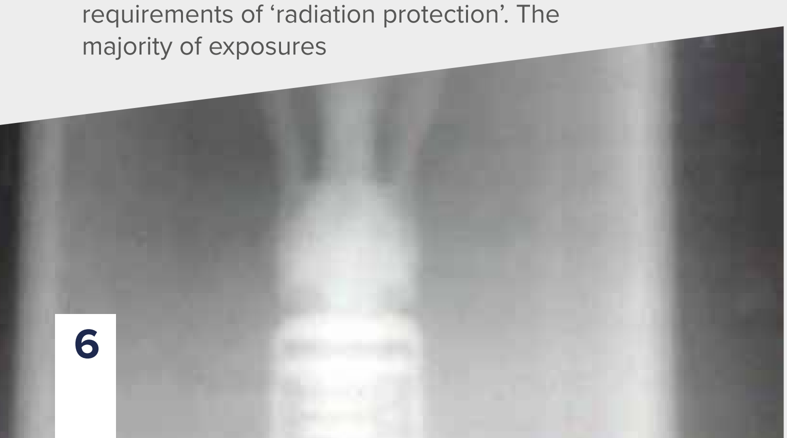
In relation to the inspection criteria, there were no challenges associated with the use of the Betatron system. The machine was very easy to set up and operate, especially with its intuitive control panel to set all of the radiograph parameters.

RESULT OF INSPECTION

Before the well operation was conducted, the 2" solid steel bar was located and proven to be within the 7" pipe.

During the well operation, the direction of the collapsed 7" pipe was proved, making the repair operation simpler.

The customer found the radiographs very helpful during the well operation and are hoping that the Betatron system will be available for future complex well operations.



JME ADVANCED INSPECTION SYSTEMS

NDT CASE STUDY
OFFSHORE INSPECTION

OCEANEERING®

- BETATRON AND WIRELESS DIGITAL DETECTOR
- OFFSHORE THICK WALL RISERS
- EXTERNAL CORROSION ASSESSMENT

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X-RAY TUBES ▪ BETATRON PORTABLE X-RAY ▪ X-RAY GENERATORS ▪ TROLLEY SYSTEMS

PORTABLE X-RAY SOLUTIONS

DIGITAL RADIOGRAPHY
OFFSHORE INSPECTION

Oceaneering Inspection Solution Combines High-Energy X-Ray and Digital Detector Array to Confirm Fitness for Service on Large-Diameter, Heavy Wall Risers Solution safely delivers high-resolution images and corrosion measurement data in near real time on an offshore installation

PROJECT OVERVIEW

In January 2016, a client approached Oceaneering for a non-destructive testing (NDT) method that would be suitable for use on two risers in the North Sea. Each of the risers had significant external corrosion scale, also known as scabs – prompting the need for verification of the risers' integrity. The goal was to extend the production timeline for the main oil line (MOL), which has a 24-inch outside diameter (OD), and the gas producer, with a 20-inch OD. The client required another year's service from the risers in order to align the completion of its necessary repairs with the next planned turnaround.

ISSUES

The operator could not support or defend continued production without developing an integrity case to prove the risers' fitness for service (FFS). Justification of FFS relies on accurate profiles of the flaws and, in this case, the remaining wall-thickness figures around the full 360-degree circumference of the risers. The scale on the risers prevented direct access to the pipe surface and could not be removed for fear of puncture and product release, bringing with it production loss and potentially serious health, safety and environmental (HSE) issues.

In 1964, Mike Hughes and Johnny Johnson formed a Gulf of Mexico diving company called World Wide Divers. The company grew in response to increasing demand for their services and in 1969 merged with two other diving companies to form Oceaneering International, Inc.

Since the beginning, the company has transformed from a small regional diving company into a global provider of engineered products and services. Today, Oceaneering develop products and services for use throughout the lifecycle of an offshore oilfield, from drilling to decommissioning. they operate the world's premier fleet of work class ROVs. Additionally, They are a leader in offshore oilfield maintenance services, umbilicals, subsea hardware, and tooling. They also serve the aerospace, defense, and theme park industries. With more than 50 years of experience providing inspection on critical infrastructure, Oceaneering deliver optimized, project-appropriate solutions that meet inspection criteria and ensure that your assets are fit for service. Their globally-deployable solutions meet your critical and time-sensitive needs for non-destructive testing.

JME
ADVANCED INSPECTION SYSTEMS

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THE OCEANEERING SOLUTION

There was no conventional, industry-accepted NDT method or hardware capable of completing the required inspection. Without verification that the risers were fit for service, the operator was potentially exposing both personnel and the environment to a high level of risk. The position of the area needing inspection – just 39 feet (12 meters) above the lowest astronomical tide (LAT) – and the operator's desire to keep operations online posed additional significant challenges. Oceaneering subject matter experts (SMEs) evaluated a range of possible options and concluded that radiography was the method with the most potential to deliver a solution; however, it was obvious that traditional X-ray or gamma sources lacked the energy required to complete the novel technique they envisaged.

Measuring the remaining wall thickness meant taking X-ray images around the circumference of each pipe tangentially. Although this is a conventional radiography technique, very powerful equipment capable of penetrating the very thick "chord" lengths of the risers was needed to complete multiple-angle exposures to ensure full area coverage. Oceaneering SMEs proposed a 7.5 MeV PXB betatron with digital detector array (DDA) radiography as a possible solution. A betatron is a very high-energy, highly penetrating source of X-radiation and had never been used offshore in conjunction with a DDA. The Oceaneering and client teams worked together to develop this industry-first operation. They established a comprehensive project plan that included trials; extensive safety planning; electrical, scaffolding and rigging teams; and the development of customized hardware.

EXECUTION PLAN

Using high-energy X-rays offshore was unprecedented, and, therefore, testing was required onshore to provide a degree of confidence that safe technical delivery was achievable. X-ray trials were conducted in a special facility in Rosyth, Scotland, in February 2016. These trials were completed using the planned tangential technique on a 24-inch-OD pipe to prove the concept. Two scoping visits were made to the platform to further understand the complexities involved with the project and to develop relationships with the client's senior management team, including the offshore installation manager (OIM) and HSE representatives. These visits provided the platform personnel with an introduction to the inspection concept, and gave the Oceaneering team the opportunity to view the work scope, particularly in relation to the positioning of the safe controlled area, exposure direction, and main personnel concentrations on the platform.

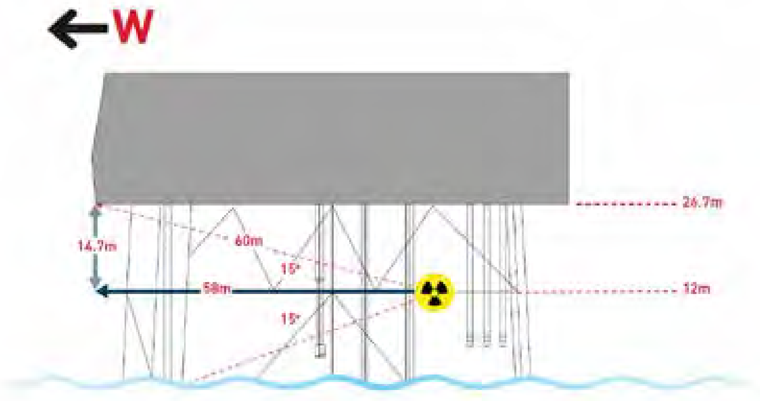
PRODUCT CASE STUDY

Offshore Inspection with the JME Betatron System

Oceaneering designed and manufactured customized hardware used to support the completion of the precise radiography. A projectspecific positioning trolley and radiation beam angle guide interfacing with the pipe flange ensured that each exposure was on target and that a comprehensive, accurate set of data was produced and used to assess the pipe thickness. The team also established a comprehensive health and safety plan, inclusive of extremely detailed exclusion areas and provisions, to ensure that personnel were not exposed to radiation. The project required an engineered scaffolding setup, and offshore preparation was completed prior to the mobilization of the radiography crew in May 2016. The radiography was conducted in 12-hour day shifts over two visits in an overall four-week time period, and was completed in June 2016.

CHALLENGES

Radiation safety, rather than a technical deliverable, was the primary challenge. This was overcome with detailed radiation dose profiling (with the beam directed toward the highrisk areas of the platform), along with special monitoring and detailed barrier plans. A twin-wire rigging system was used to lift and lower the heavy equipment from the deck level through a floor grating hole down to the scaffolding platform. Manual handling and positioning of the 220-lb (100-kg) accelerator head at the workface was achieved by fabricating a bespoke, wheeled support trolley and by rigging an overhead lifting beam in the radiation habitat. The location of the inspection site was only 39 feet (12 meters) from the sea, and, therefore, moisture, sea spray and salt, in combination with high winds and gusting, precipitated the need for an engineering-designed scaffold and weatherproofed habitat. Challenges in cable management, along with routing of the necessary communications and power from the system control habitat at emergency shutdown valve (ESDV) levels, were identified and overcome.

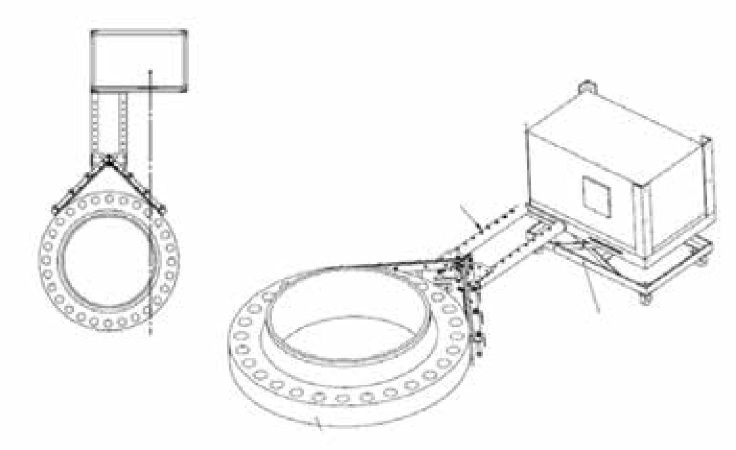


PRODUCT CASE STUDY

Offshore Inspection with the JME Betatron System

EQUIPMENT HIGHLIGHTS

- 7.5 MeV MXB betatron accelerator head
- Splash-proof covers for the power supply unit (PSU) and the accelerator head
- Special positioning trolley and angling device
- Specially fabricated collimation solution
- High-energy certified TRACERCO™ T202 Dose Rate Monitors
- A high-resolution, wireless digital detector array to deliver near-real-time digital X-ray images

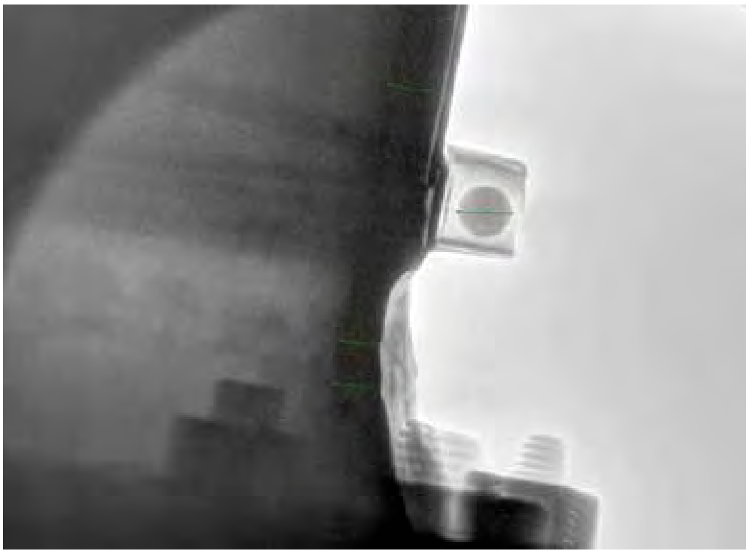


PROJECT HIGHLIGHTS

- First time that high-energy X-rays and digital detector array radiography were used in combination on an offshore installation
- First time that the “tangential” technique has been used on this pipe thickness to provide wall-thickness information through heavy external corrosion scale
- First time that this information has been used for such a high-profile FFS exercise

RESULTS

The radiography was completed successfully, and the client was able to use the data produced to establish the risers’ FFS. The images and calculations generated confirmed that the risers were fit to continue production at specific pressures appropriate for the required timescale. More importantly, the safety of the platform and its personnel was confirmed, and approval from the HSE team further established the suitability of the method used.



For this challenge, Oceaneering investigated possible methods, identified a solution, and completed the inspection of the risers by using its expertise in asset integrity and inspection methodologies. The solution provided significant cost savings and superior integrity assurance in a busy production environment on an offshore installation. The project identified a successful NDT solution for a degradation issue that is typically present on the many offshore installations with more than 20 years of production life. Oceaneering is confident that this extremely powerful inspection combination can be a useful tool in the U.K. Health and Safety Executive’s Key Programme 4 (KP4) Ageing and Life Extension (ALE) program’s search for inspection options.

JME ADVANCED INSPECTION SYSTEMS

NDT CASE STUDY

LOCATING STUCK PIPELINE PIG USING HIGH ENERGY X-RAYS AND DIGITAL RADIOGRAPHY DETECTOR

Oceaneering helps operator solve major flow disruption issue

OCEANEERING®

- **JME PORTABLE X-RAY BETATRON 7.5MEV**

DIGITAL RADIOGRAPHY

JME Technology Used to Locate a Stuck Pipeline Pig.
JME PXB system used to solve flow disruption issue.

THE FOLLOWING CASE STUDY, WRITTEN BY AND AVAILABLE ON OCEANEERING'S WEBSITE, DETAILS THE USE OF JME'S BETATRON TO SOLVE A COMPLEX CHALLENGE INVOLVING A PIPELINE PIG THAT WAS DISRUPTING OIL FLOW TO THE ONLINE TERMINAL.

PROJECT OVERVIEW

An oil and gas pipeline operator contacted Oceaneering because an in-line inspection (ILI) pig was stuck in one of its pipelines in the North Sea. The pig had broken, and while one portion was recovered at the onshore reception facility, the rest remained stuck at an unknown position within the pipeline and was preventing oil production to the onshore terminal. The pipeline was suspected to be full of crude oil and wax deposits.

ISSUES

Production disruption meant large revenue losses, and the remediation plan needed not only an expedited solution, but one that had the best probability of positively identifying the missing pig's location.

THE SOLUTION

There were no obvious known non-destructive testing (NDT) solutions available for obtaining non-intrusive inspection (NII) data or visual images of the pig with any confidence. However, radiography had potential as a viable option for targeted inspections.

Conventional radiography using high-energy gamma radiation was considered and ultimately rejected based on the method's insufficient penetrating power. The target areas of the pipeline included thick tee sections and complex non-return valves (NRVs). An additional consideration was the likelihood of the larger diameter pipe potentially being full of heavy crude wax.

Oceaneering was able to recommend JME's Betatron high-energy X-ray system as a possible solution. The Betatron system, also known as a cyclotron, is normally used in a purpose-built exposure compound onshore to X-ray components with thicknesses up to 250mm. It is, however, seldom used for open site-based locations; one of the main challenges is assuring personnel safety during the operations and setting up a 'Controlled Area'.

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www.jme.co.uk

EXECUTION PLAN

The pipeline blockage was discovered in 2018; initial recovery operations using pressurization regimes and cleaning pigs were attempted during 2019. An unfortunate outcome of these intervention operations was that part of the pig broke off, but was recovered at the terminal pig trap. However, the fear was that other loose pig parts may remain in the pipeline along with the rest of the pig.

Oceaneering developed a timeline that included a data verification review using a similar data set from previous work involving a stuck pig and Betatron; pipeline exposures in our specialized facility at the Rosyth, U.K., dockyard; a presentation of the intended solution to the client; a detailed risk assessment of the site; and mobilization of equipment and specially trained personnel for the work from our head office in Aberdeen.

CHALLENGES

Several challenges presented themselves as the team prepared to execute the project plan, including:

- Radiation dose levels
- Stable power supply for Betatron
- Moist/salty air environment
- Scaffolding management
- Nucleonics
- Site personnel training

To resolve the challenges, the Oceaneering team put controls in place, lead sheeting, and collimation to attenuate the beam and test exposure to ensure radiation dose levels were properly managed. Special job-specific and site-specific local rules were adhered to, and a high-energy monitor adequacy trial was completed.

The team also ensured that adequate and stable power supply to the Betatron unit could be supplied by working closely with the site’s electrical supervisor to ensure that there would be no power output spikes.

To account for the moist and salty air environment, the team ensured that equipment was supplied with adequate covers and control habitat.

A scaffolding management protocol was implemented. This consisted of a lift plan and local manual handling and storage on the scaffold itself. The accelerator was stored in the transport case overnight. The team also installed a load-bearing overhead beam with shackle to support lifting. In addition, the group enlisted a specialized engineering design team for scaffold construction.

To ensure the beam did not affect nucleonic instrumentation, the team established precise beam control and collimation directed away from the pressure plant and equipment likely to be affected.

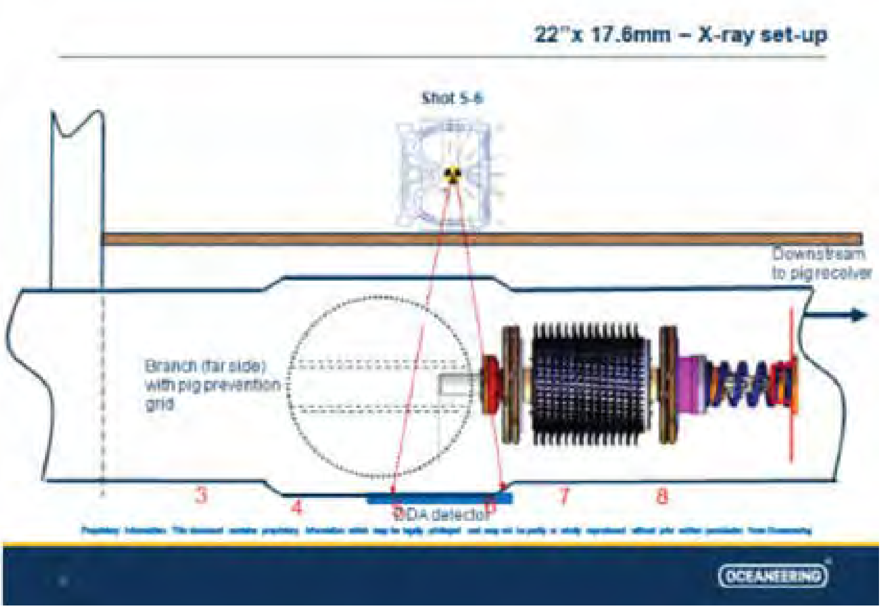
For safety and site personnel radiation awareness, the team conducted on-site training and toolbox talks.

The team provided daily scheduled calls to the site for project management fitness for service (FFS) input and image assessments from subject matter experts (SME).

To identify and inspect additional risks, the team conducted a daily risk assessment and perimetry regime.

RESULTS

By using this innovative solution, the customer was able to resume pipeline production operations after only three months. We were able to positively confirm the pig position and the absence of pig debris in the tee prevention bars and inside the NRV. The pig's location would have prevented valve closure or even caused damage to the valve internals during the closure which would have required a major pipeline intervention and workover to replace the valve. Around 20 m of pipeline was radiographed before eventually finding the pig. One of the main X-ray set-ups and actual X-ray digital image through the process thick wax product is shown.



CASE STUDY ORIGINALLY PUBLISHED AT
WWW.OCEANEERING.COM/NEWS-MEDIA/CASE-STUDIES/

JME ADVANCED INSPECTION SYSTEMS

NDT CASE STUDY

JME PXBMJ BETATRON VALIDATION FOR USE IN INSPECTION OF FIRE PROOFED STRUCTURAL STEEL

PRECISION NDT

- **DEVELOPMENT QUALIFICATION ON FIRE PROOFED STRUCTURAL STEEL UTILIZING HIGH ENERGY PHOTONS**

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NDT CASE STUDY
JME PXBMJ BETATRON VALIDATION

REPORT PREPARED BY:
TRENT LONEY ASNT LEVEL III # 138039
DANIEL PROFFER ASNT LEVEL III # 313490

INITIAL CONCERN

The catalyst for this study was the concern that main structural I-beams at a Petrochemical facility could be suffering from degradation due to the fracturing of a fire-resistant concrete that was applied during installation. The initial goal is to locate possible damage caused by oxidation due to water ingress through the fractures that could affect the integrity of the structure as well as determine the extent of the damage revealed without the removal of the fire protectant.

COMMENTARY OF ANALYSIS:

This paper will focus on the ability of high energy X-Ray photons to penetrate structural steel encased in fire proofing material. Based on the previous results, as demonstrated by the Iridium 192 image below and considering the energy levels associated, it is hypothesized that to penetrate a specimen consisting of a 12” I-beam with a web thickness of .750” and flange thickness of .500” encased in 14” x 16” fireproofing concrete, that energies of 2 MeV or greater will be necessary to reveal artificially induced degradation. These discontinuities consisted of 3 drilled holes .500” in diameter at 3 different depths 1/4t (.1875”), 1/2t (.375”), and 3/4t (.500”). These depths were chosen in an effort to simulate expected damage that could jeopardize the structural integrity of the beams at specific areas of concern.

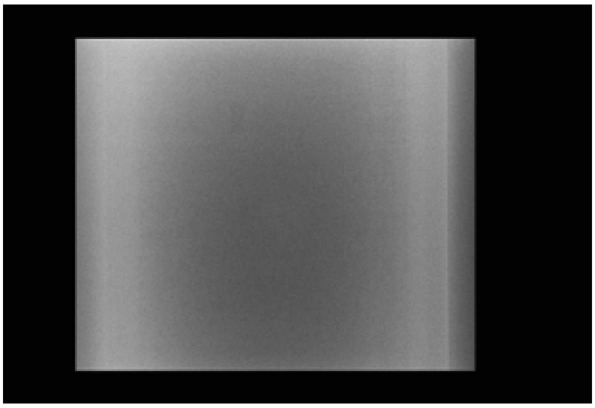
PREVIOUS ATTEMPTS:

When the concern was initially revealed, a concerted effort was made to radiograph the suspect area using digital radiography (DDA) and an Iridium 192 isotope and 400 KV X-Ray tube. While both Iridium and 400 KV were successful in producing an image, the image lacked definition and sensitivity to reveal the extent of the damage. It was noted the aggregate within the concrete drastically attenuated the photons of the radioisotope. After assessing the image, along with the procedure parameters, it was pondered that utilizing shorter wavelength photons, effectively reducing the amount of particulate interaction within the specimen, should provide the desired definition and sensitivity.

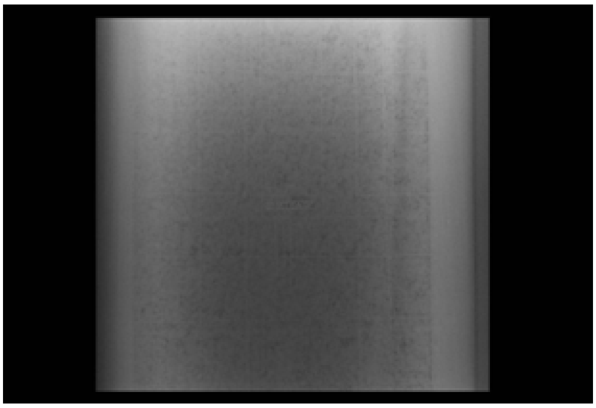
NDT CASE STUDY
JME PXBMJ BETATRON VALIDATION

PXB
PORTABLE X-RAY BETATRON

Ird. 192 (.35 MeV Primary Spectrum) Image:

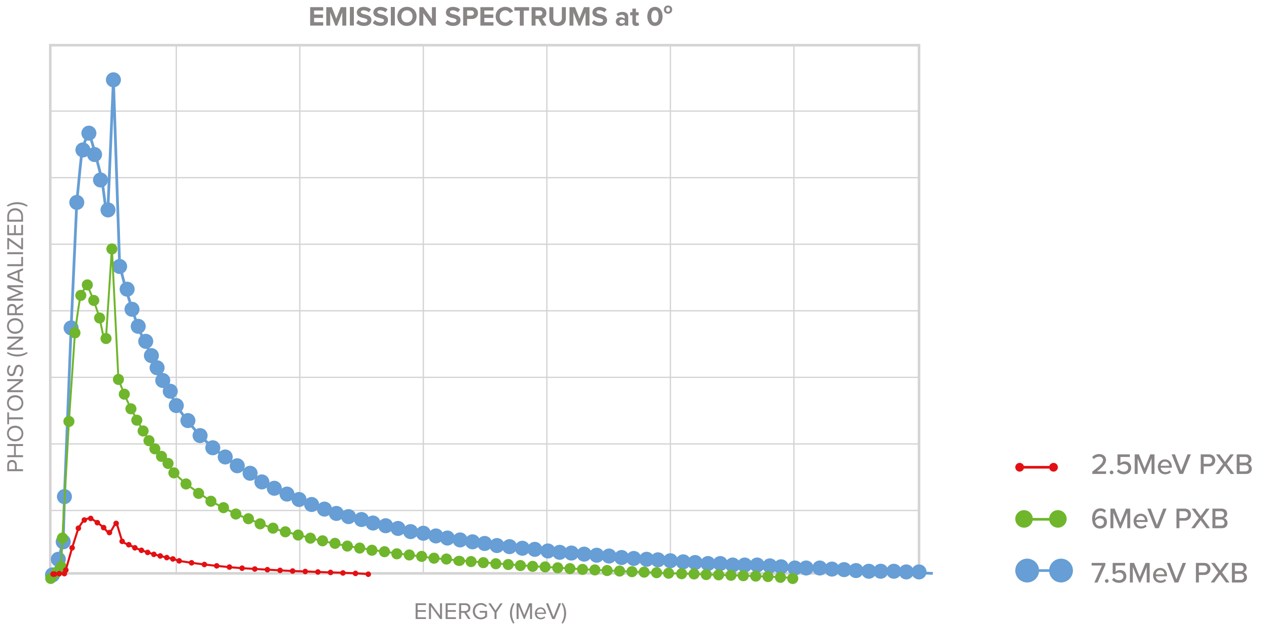


X-Ray tube shot: 400 KV Distances: 9.5” from concrete



HYPOTHETICAL CONCEPT:

During our attempt with Iridium 192 and 400 KV, it was discovered that the thickness and characteristics of the concrete drastically attenuated the photons in the bandwidth provided by the radioisotope and X-Ray tube, Irdidium energies are composed of 10 distinct energies ranging from .21 to .61 MeV with the primary energy at .35 MeV, (there is some debate depending on the referenced material) and the spectrum upon energies found with the X-Ray tube at a maximum output of 400 KV. It is postulated that the longer wavelengths of these energies are being heavily absorbed within the cement, and significant buildup is causing excessive scatter to the image compromising sensitivity and definition. The basic principle here is to eliminate the excessive scatter by lessening the particulate interaction, electron/positron emission associated with the pair production principle and attempt to penetrate the specimen with photons in the 2 to 7.5 MeV range. Inherently, X-Rays produce an energy spectrum with the highest output at the maximum capacity of the accelerator. This spectrum, although consisting of all energies, possess bands of energies that have more intensity than other energies within the spectrum.



Taking notice of the primary bands of energies, it is realized that the primary bands decrease in wavelength as the energy is increased. The main spectrum, at any of the three energies listed, is not considered optimal. The primary bands are below or at pair production energy (1.02 MeV), which emit ionizing particles as well as photons that increase forward scatter, reducing definition and sensitivity. The options available to eliminate these unwanted energies are to; filter out the undesired energies, use the higher energy levels to increase the percentage of the desired energies to the digital detector array in the shortest time possible to reduce the forward scatter and eliminate particle interaction, or a combination of both. A series of tests were conducted using different combination of these options to determine which option provided the most optimal image quality. It should be considered, that circular particle accelerators only function at a percentage of the tube potential when variable energy levels are selected. For example, when running a 7.5 MeV accelerator at 2.5 MeV the tube is only performing at 5% of the tube potential, when set to 5.0 MeV the tube is performing at 33%, and only 7.5 MeV is the output at 100% capacity. These tubes also pulse, so to gain maximum efficiency, synchronization of the detector and the tube would prove advantageous. For this exercise, the tube and the detector were not synchronized.

Fire proofing material: A fire retardant concrete could not be sourced; however, in an effort to conduct the testing, a cement/sand mixture with aggregate up to .5” was used. This particular mixture does not accurately represent the fire retardant used in the original specimen. As the retardant is known to be less dense than typical concrete and the aggregate is considerably smaller in size and less dense than the rock used, the mindset here, is that since concrete mixing is not an exact science and different materials may have been used for the creation of the concrete for different columns, if we are able to reveal the artificial damage within the blend that is more dense than the fire proofing sample provided, the probability of disclosing damage with less volume will be considerably higher; consequently increasing the sensitivity and definition.

INITIAL TESTING WITH HIGH ENERGY X-RAYS:

SPECIMEN:

I-Beam Dimensions:

Length: 12”

Width: 13”

Height: 12”

Web Thickness: .750”

Flange Thickness: .500”

Flaw Dimension 1/4t: Diameter .5” x Depth .1875”

Flaw Dimension 1/2t: Diameter .5” x Depth .375”

Flaw Dimension 3/4t: Diameter .5” x Depth .5625”

SIMULATED FIRE PROOFING MIXTURE:

Length: 16”

Width: 14”

Height: 12”

NDT CASE STUDY
JME PXBMJ BETATRON VALIDATION

PXB
PORTABLE X-RAY BETATRON

TECHNICAL SPECIFICATIONS

PXB 7.5

Peak X-Ray Output	2 to 7.5 MeV
Dose Rate at 1m (3.3ft)	>5R/minute
Focal Spot Size	0.3 x 3 mm
Duty Cycle Radiation Beam	75% per hour
Beam Coverage	250 x 250mm @ 1m
Radiographic Sensitivity	Down to 1%

Supply Voltage	Single-phase, 110V or 220V, 50/60Hz
Adjustment Range of Energy	2.0 to 7.5MeV in 0.1MeV increments
Power Consumption	3.0kW 13.6A @220V, 27A @ 110V)

DIMENSIONS AND WEIGHT

Accelerator (Radiator)	600 x 400 x 230	109kg
Power Unit	590 x 380 x 360	60kg
Control Panel	130 x 200 x 30	0.5kg

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*Test #8 and #11 have been eliminated as there was no additional clarity or definition revealed in the image.

TEST 1

Source to Object Distance:	36”	Exposure in Seconds:	110
Source to Detector Distance:	53”	No. of Frames:	5
Object to Detector Distance:	17”	Megaelectron Volts (MeV):	2.5
Focal Spot:	.3mm x 3mm, .119”	Filters Applied:	Edge DR 1

Comments: 2.5 MeV proved to penetrate the specimen at 110 seconds/frame. The 1/2t and 3/4t holes were visible; however, the excessive exposure time and inability to pull the 1/4t hole was unfavorable. It was decided to increase the exposure time to deliver more dose to the plate.

TEST 2

Source to Object Distance:	36”	Exposure in Seconds:	200
Source to Detector Distance:	53”	No. of Frames:	5
Object to Detector Distance:	17”	Megaelectron Volts (MeV):	2.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1

Comments: 200 seconds proved to reveal all three holes, even at an excessive object to plate distance. This was tested, in the case, physical limitations did not allow the plate to be in intimate contact with the specimen. It was noticed during the site visit that there were a number of utility lines and the like supported by the beams that are intended to be evaluated during the investigation. Although positive results were realized, the exposure time was considered excessive, therefore the object to detector distance was lessened and source to object was increased.

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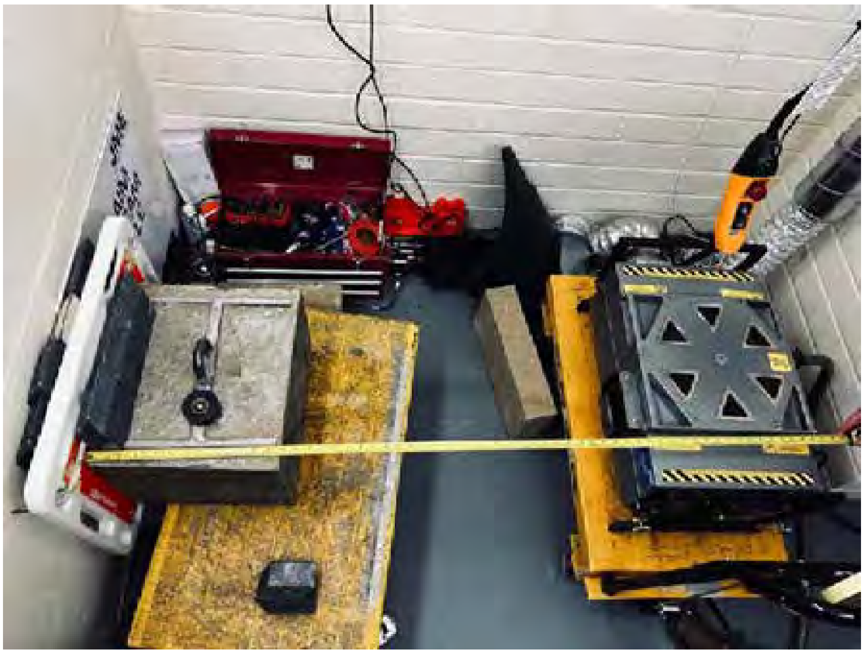
TEST 3

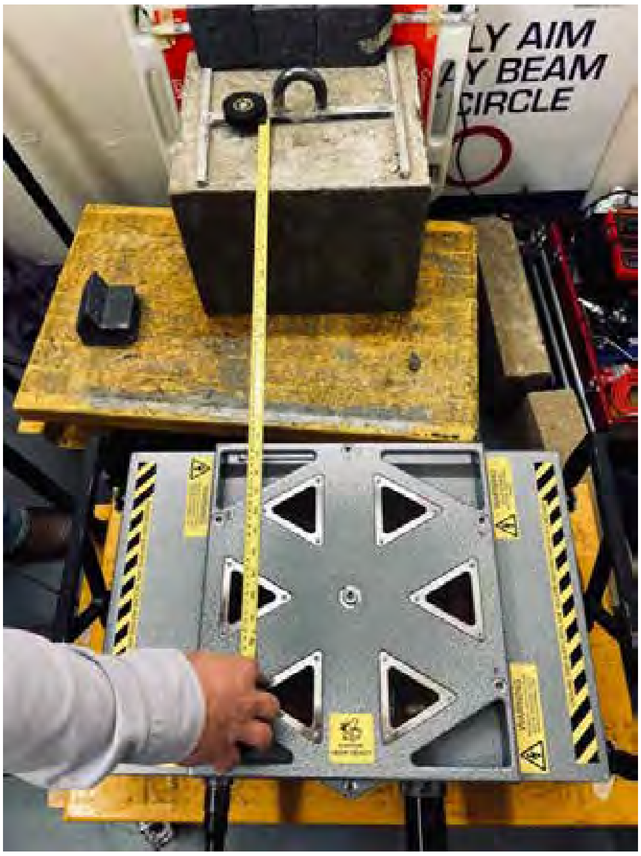
Source to Object Distance:	45”	Exposure in Seconds:	115
Source to Detector Distance:	53”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	2.5
Focal Spot:	.3mm x 3mm, .119” .119” Diagonal	Filters Applied:	Edge DR 1

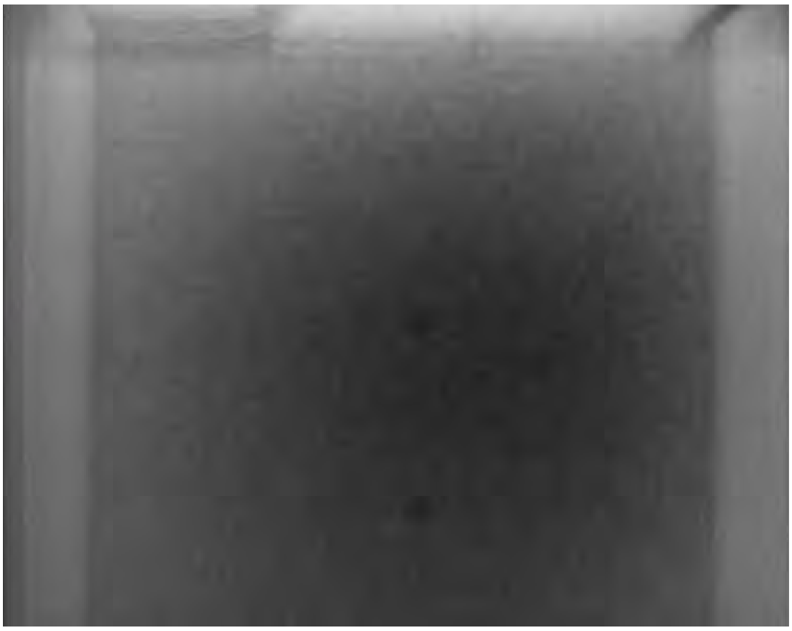


Comments: Test 3 proved favorable with added definition and sharpness to the 1/4t hole; however, the exposure time was still not desired. It was decided to increase the MeV, decrease the source to object and decrease the time.

TEST 4

Source to Object Distance:	30”	Exposure in Seconds:	90
Source to Detector Distance:	38”	No. of Frames:	5
Object to Detector Distance:	9”	Megaelectron Volts (MeV):	5.0
Focal Spot:	.3mm x 3mm, .119”	Filters Applied:	Edge DR 1

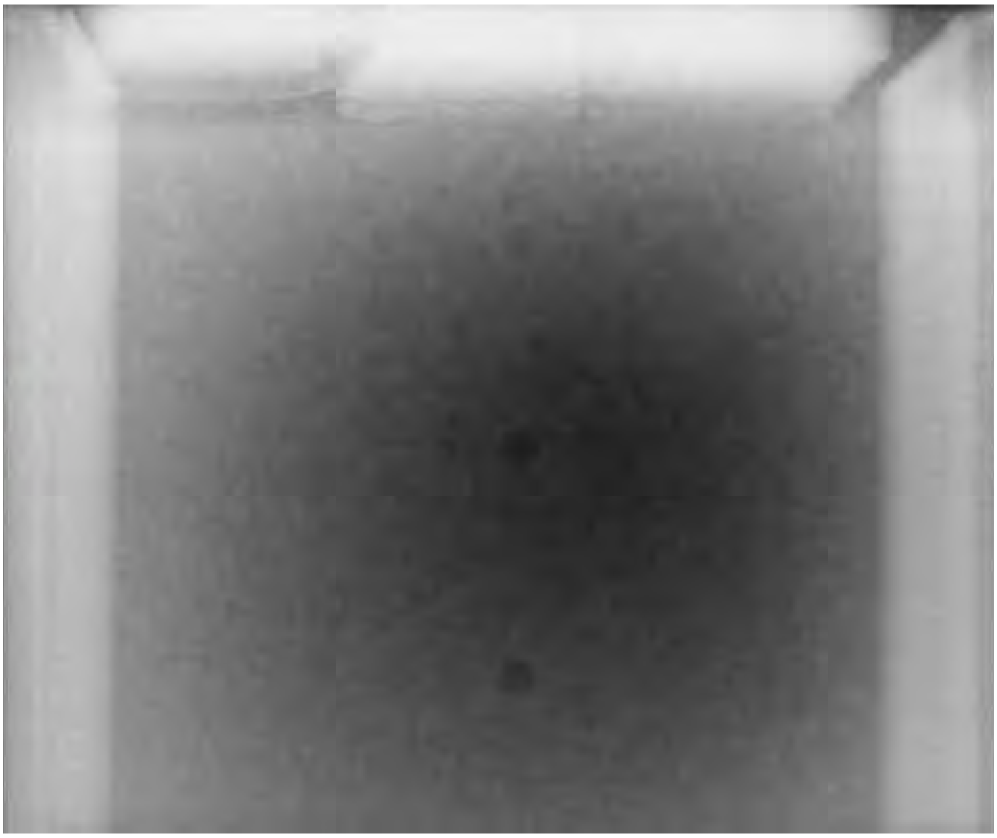




Commentary: Test 4 provided optimal definition and sensitivity, less mottling of the image was realized, which gave the precedence to increase the MeV to the maximum output of the tube and achieve 100% efficiency. It is deduced that the reduction in mottling is due to the decrease in wavelength as a result of the MeV increase.

TEST 5

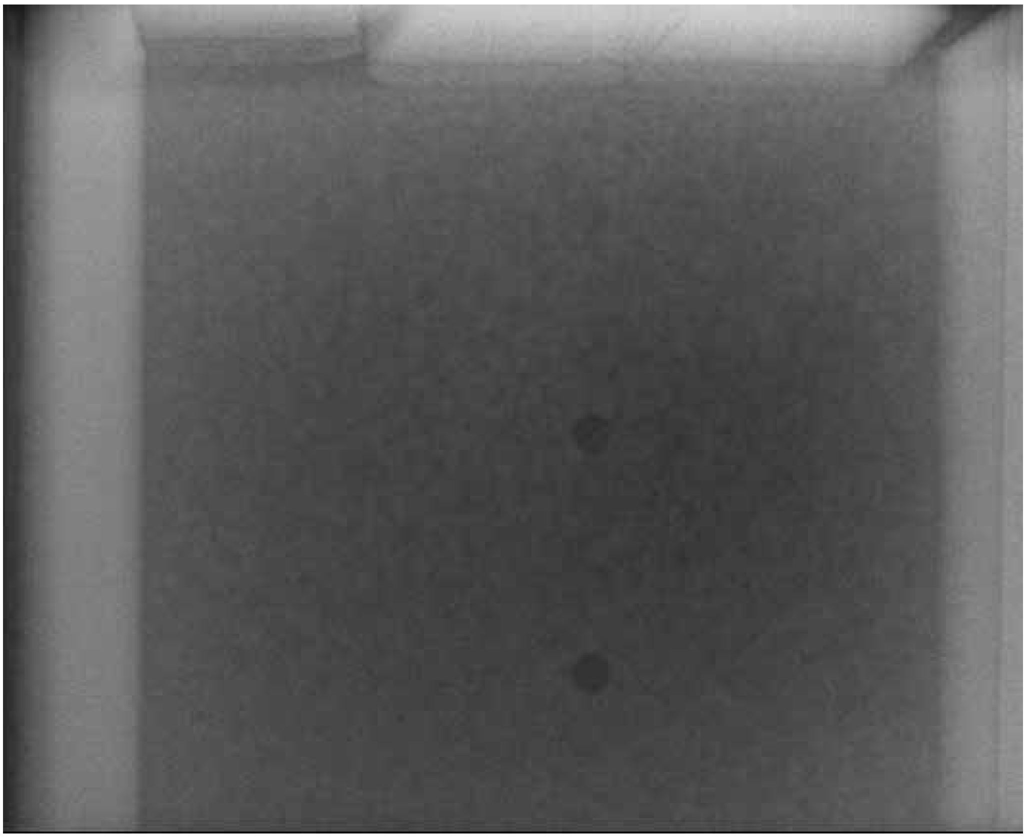
Source to Object Distance:	30”	Exposure in Seconds:	34
Source to Detector Distance:	38”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1



Comments: As one can see, the wavelength reduction decreased the forward buildup by decreasing the probability of high energy photons interacting with the aggregate resulting in less mottling on the image. The main spectrum of energy (0 to 1.5 MeV) produced during a 7 MeV exposure is has very little effect when reducing the time of the exposure (imagine the decrease dose to the plate at 2.5 MeV for 115 seconds) however, the > 1.5 MeV photons produce enough interaction within the steel to lessen the concrete and aggregate effect to the image and consequently increase the steel’s effect on the image.

TEST 6

Source to Object Distance:	30”	Exposure in Seconds:	25
Source to Detector Distance:	38”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1



Comments: Favorable effects when reducing the shot time and all other parameters are kept constant.

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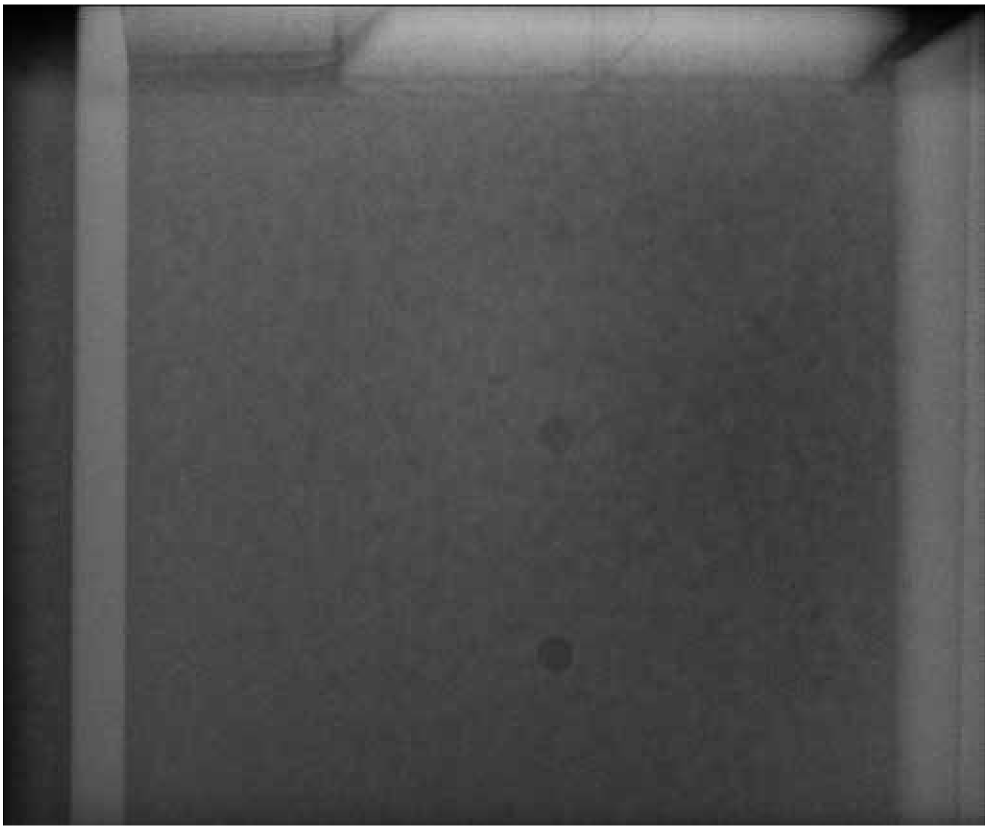
JME PXBMJ BETATRON VALIDATION

PORTABLE X-RAY BETATRON

TEST 7

Source to Object Distance:	45”	Exposure in Seconds:	40
Source to Detector Distance:	53”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1



Comments: Increased the source to object distance in an effort to increase the sensitivity, unfavorable results were witnessed. The longer the time the more scatter occurred which increased the mottling.

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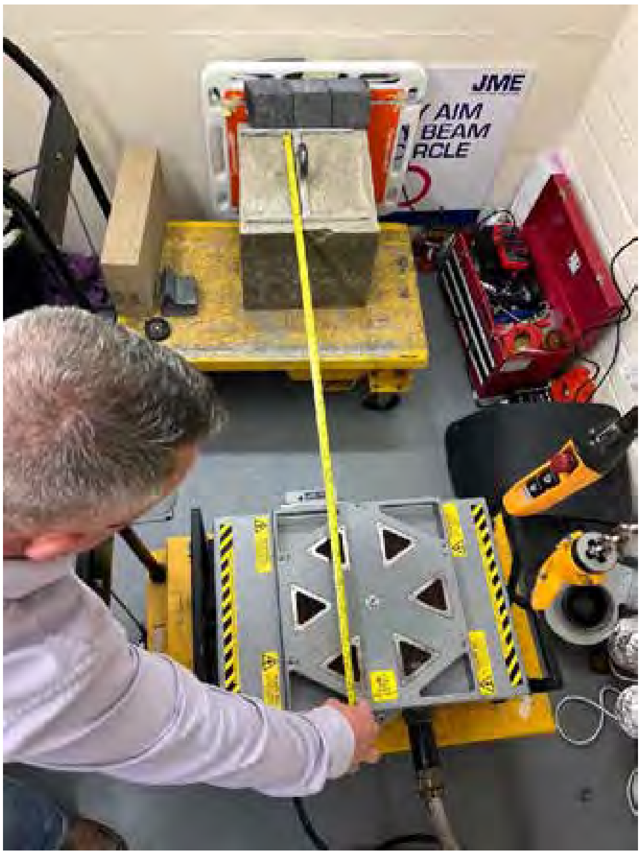
TEST 9

Source to Object Distance:	45”	Exposure in Seconds:	40
Source to Detector Distance:	53”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1
Notes:	Rotated 90 degrees		



Comments: Although we do not intend to expose the specimen through the thicker cross section, it was decided to attempt one of these images. You will notice that on the bottom right-hand portion of the web of the I-beam there is a noticeable loss of material, this material loss is from a gouge (2.07 mm) ground into the web on the source side of the IBeam. This is a phenomenal revelation given that this discontinuity is being revealed through 13” of steel and is not noticeable through 13.250” of concrete and ¾” of steel. This is a real testament of the penetrating power of the accelerator and the scatter interruption when shooting through concrete.

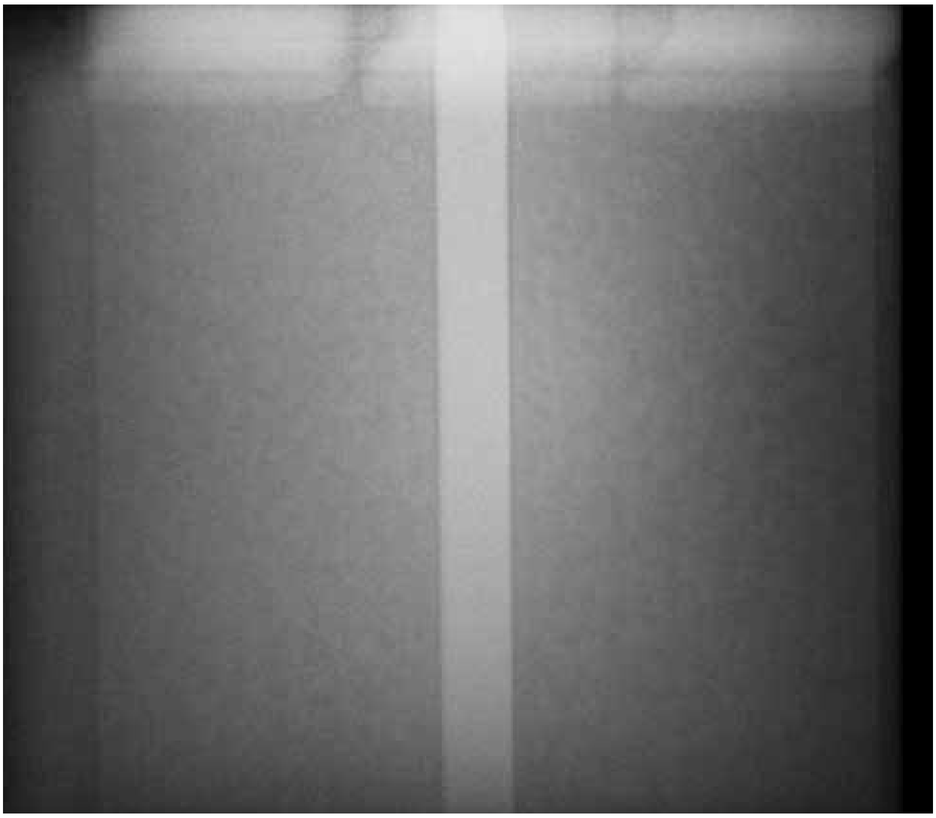
NDT CASE STUDY
JME PXBMJ BETATRON VALIDATION

PXB
PORTABLE X-RAY BETATRON

TEST 10

Source to Object Distance:	30”	Exposure in Seconds:	40
Source to Detector Distance:	38”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1

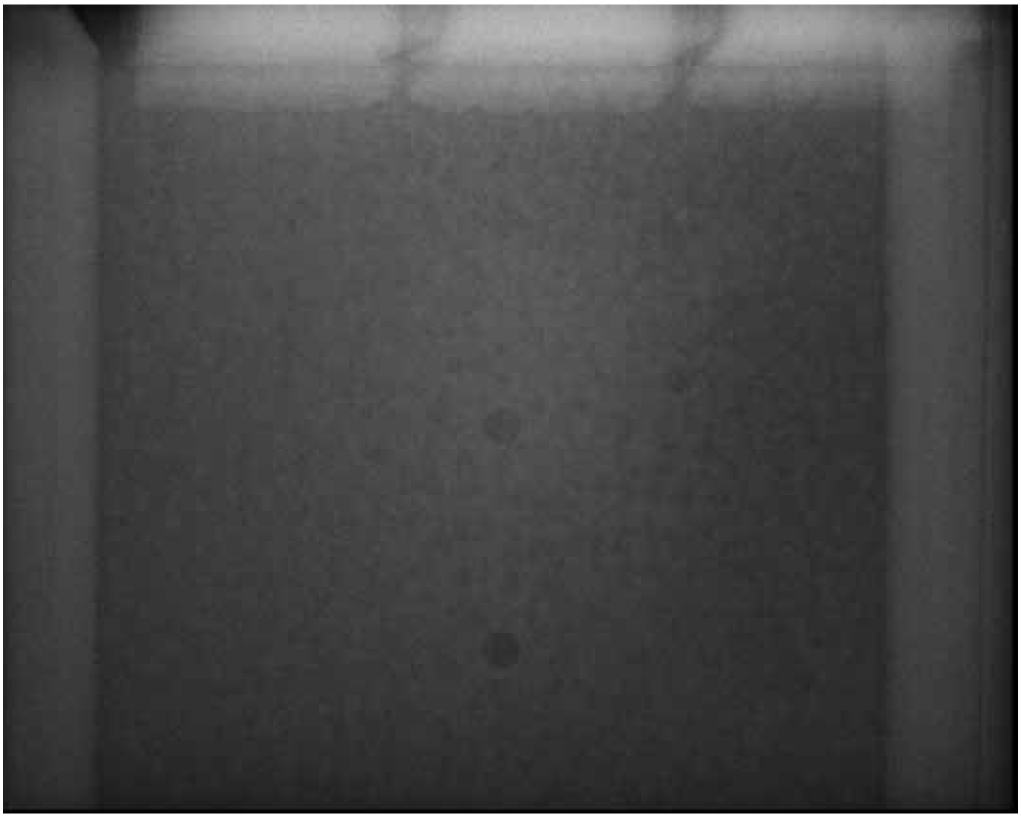
Directly aimed at side D defect.



Comments: This exposure was taken to ascertain whether taking a radiograph through the long axis of the specimen would expose a 2 mm artificial discontinuity in the flange section of the I-beam. No discontinuity was revealed, this backs the theory that the scattering effects of the concrete are exponentially higher than any scatter that occurs within carbon steel. We can see a 2.07 mm indication through 13” of steel and approximately 2” of concrete but we cannot reveal a 2 mm discontinuity through 1” of steel and 15” of concrete.

TEST 12

Source to Object Distance:	30”	Exposure in Seconds:	90
Source to Detector Distance:	38”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1
Notes:	¼” Pb After holes drilled, one filled with water. 4 Leads placed on specimen side.		



Comments: In order to ascertain the sensitivity levels in the image and determine if the insulation was not in intimate contact with the part, which could consequently allow and retain water ingress, an 8mm hole was drilled into the part to simulate this scenario. To eliminate any excess scatter approximately 1/4” of Pb was first placed on the source side of the part for the examination. The drilled hole was visible; however, it was believed that placing the filter at the detector side of the plate would prove favorable.

NDT CASE STUDY
JME PXBMJ BETATRON VALIDATION

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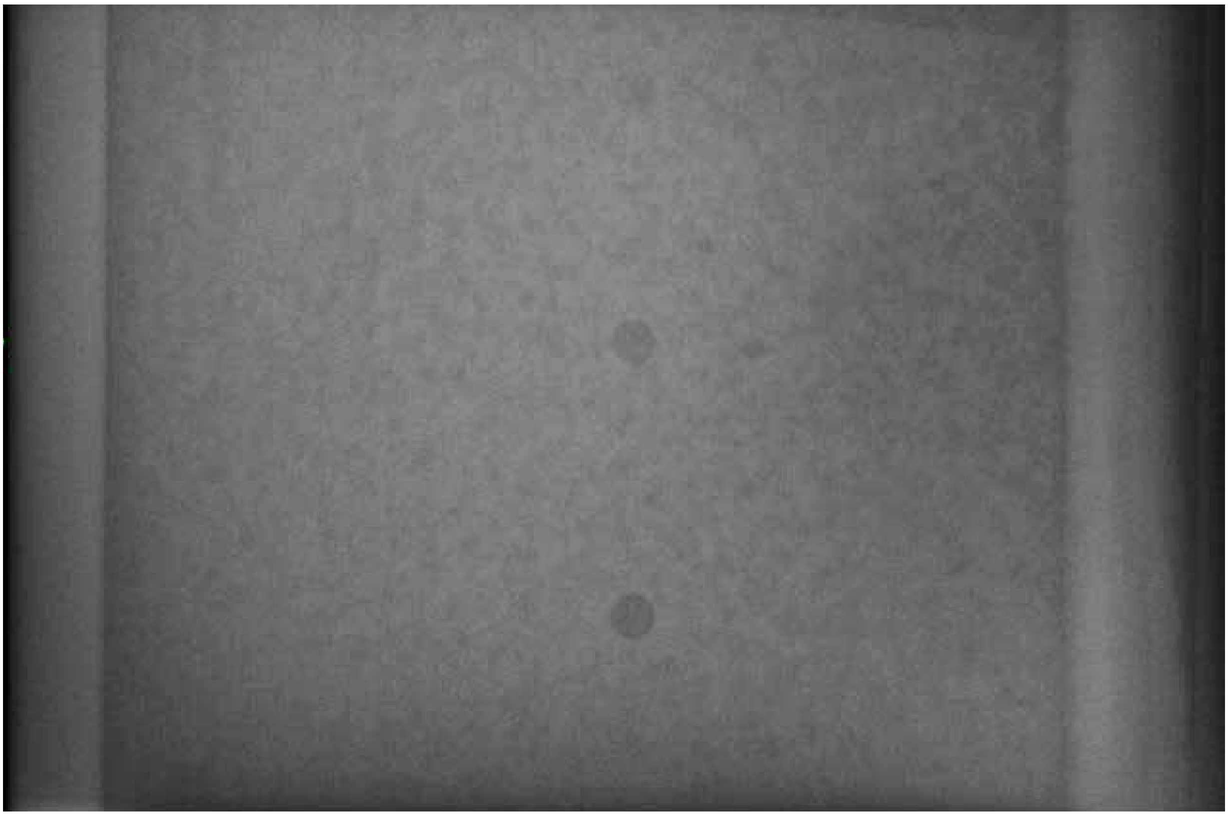
TEST 13

Source to Object Distance:	30”	Exposure in Seconds:	90
Source to Detector Distance:	38”	No. of Frames:	5
Object to Detector Distance:	8”	Megaelectron Volts (MeV):	7.5
Focal Spot:	.3mm x 3mm, .119” Diagonal	Filters Applied:	Edge DR 1
Notes:	¼” Pb Leads on detector side after holes drilled.		



Comments: As hypothesized, placing the filter on the detector side of the plate proved to reveal favorable results. The drilled 8mm hole is clearly seen the image.

SUMMARY

As postulated, using a high energy particle accelerator was indeed successful in revealing the ¼ t, ½ t, and ¾ t holes in the specimen. Improved definition and sensitivity were witnessed at the higher energy levels as the higher energies allowed for less exposure time which decreased the forward build-up typically associated with longer exposure times and lower energies. Pb filters of ¼” at the detector proved to be an appropriate filter to increase sensitivity levels which enabled the detection of not only ¼ t x ½” diameter hole, but also revealed an 8mm hole within the concrete itself. It is believed that the sensitivity achieved is more than adequate to assess the integrity of the structural I-beam; however, after obtaining the data, it is recommended that engineering calculate the criticality of the degradation.

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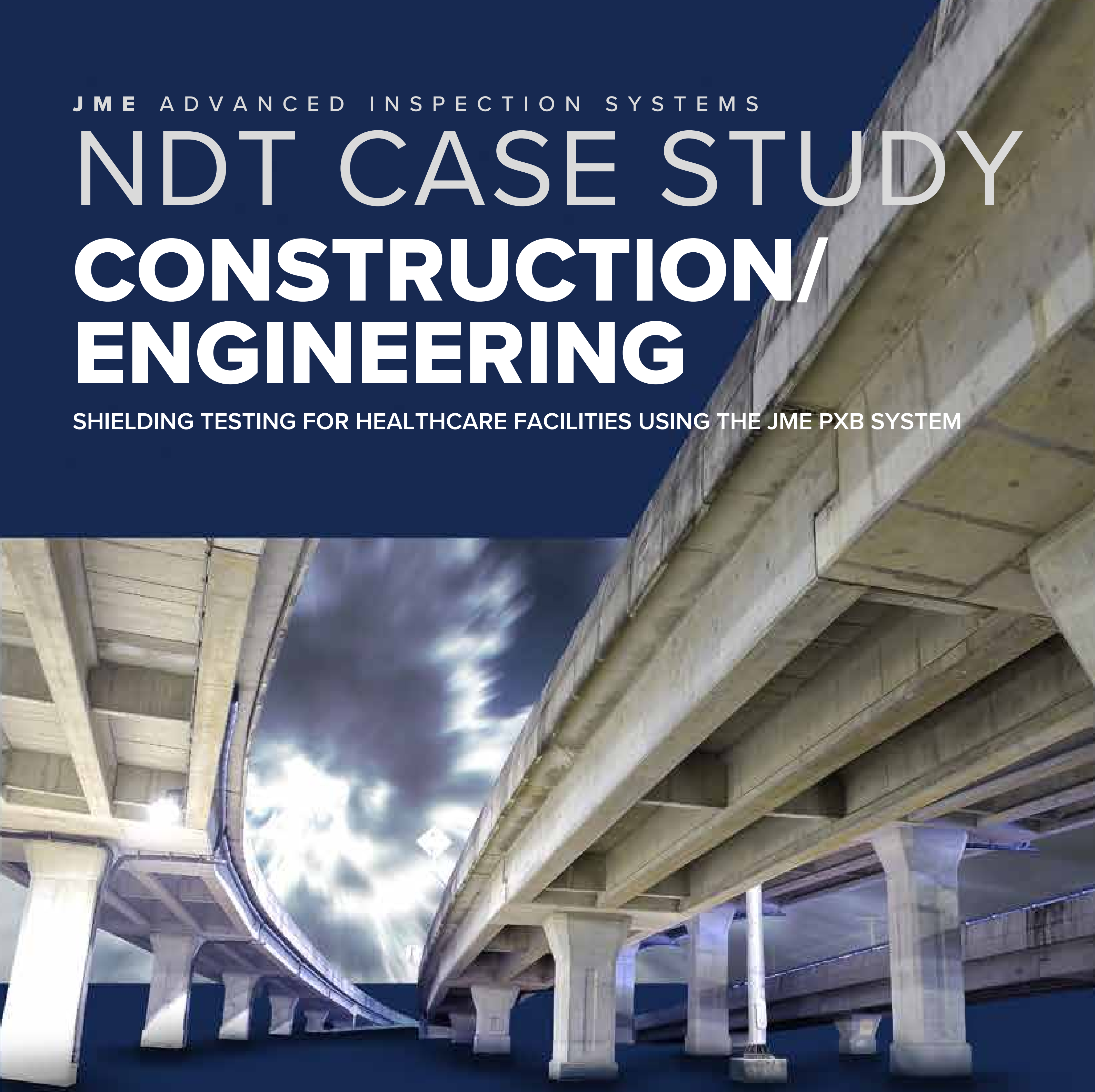
NDT CASE STUDY

CONSTRUCTION/ ENGINEERING

SHIELDING TESTING FOR HEALTHCARE FACILITIES USING THE JME PXB SYSTEM



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PRODUCT CASE STUDY

Shielding Testing for Healthcare Facilities

INSPECTION USING THE JME BETATRON SYSTEM

In the UK, facilities in which ionising radiation is used, are subject to The Ionising Radiations Regulations 2017 (IRR17). Under these regulations, employers are required to consult a Radiation Protection Adviser (RPA) regarding the plans for any new or modified facilities and specifically the control measures which are implemented to ensure exposure to ionising radiation is kept as low as reasonably practicable (ALARP). Aurora has experience of providing this advice for all uses of ionising radiation in the healthcare sector, including proton beam therapy, traditional external beam radiotherapy, brachytherapy, nuclear medicine, radiopharmacies, medical isotope production facilities and diagnostic radiology equipment. Aurora uses the JME Portable X-Ray Betatron (PXB) System for Shielding Integrity Testing (SIT) within radiotherapy bunkers. SIT provides confidence to both the construction partner and the healthcare provider that the facility has been constructed in accordance with the design before it is handed over. SIT uses a mobile radioactive source, which allows more comprehensive testing than is possible with a fixed clinical source. The test source is chosen to match the shielding provided, which allows testing to take place even when adjacent spaces are occupied.

THE BENEFITS OF THE JME PXB SYSTEM

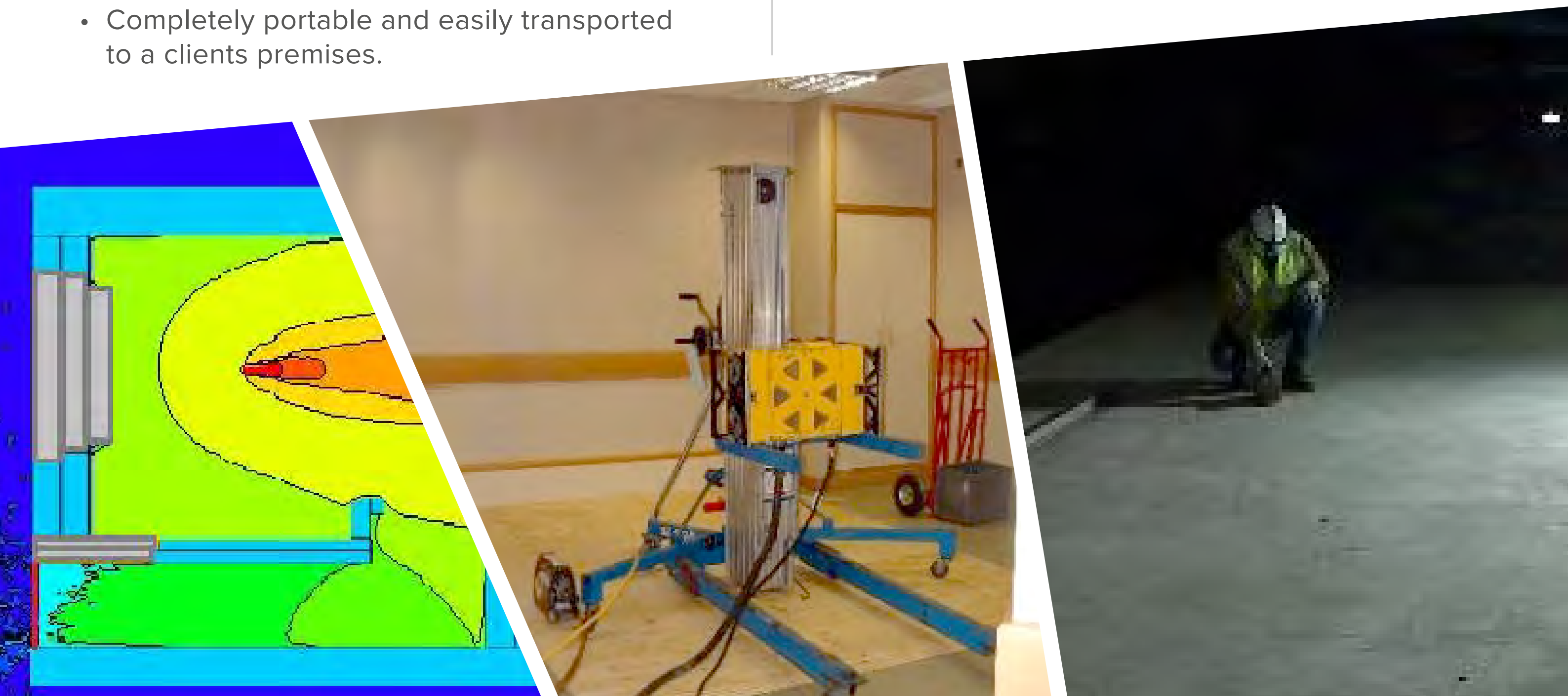
Why was a Betatron chosen for this particular application and what specification was used?

- It is powered from a standard single phase 230 volt electricity supply which is readily available on the client's premises.
- It is controllable, allowing the user to select higher or lower energy x-rays. This enables operator doses to be minimised and the x-ray output matched to the structure being examined.
- It is easy to terminate an exposure in an emergency if required – in the event that an exposure needs to be terminated quickly, this is easily achieved with the control panel by either using the Emergency Stop (quick action - sharp tap to the Emergency Stop button) or switching off using the Betatron operating key.
- It is reliable, producing a stable x-ray output with repeatable results across each energy range.
- Completely portable and easily transported to a clients premises.

PROJECT DETAILS

Testing of the facility with the JME Betatron system produces x-ray transmission data. Typically, upwards of 100+ data points will be assessed dependent on the size of the structure and the nature of the clients' requirements. The data is then analysed off-site and a 'Shielding Integrity Test Report' is produced.

If you would like more information regarding the JME BETATRON SYSTEMS, please email sales@jme.co.uk or telephone +44(0)1502 500969



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PXB:RF

CONTROL PANEL + REMOTE HANDSET

PORTABLE X-RAY BETATRON

JME WIRELESS BETATRON SYSTEM

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JME's New wireless Betatron system is available in both 6 and 7.5MeV versions. These systems have been designed to function with both the conventional wired control panel and the innovative new wireless handset. Coupled with a JME Radio Repeater the user can now operate the system from a range of up to 1,7KM. This has improved safety and allows the Betatron to be used in a greater range of inspection applications.

JME BETATRON REMOTE HANDSET

The handset allows the user to wirelessly configure the system prior operation. It also provides the user with real time feedback on the status/operation of the system whilst in use. The operator can review and adjust parameters which are key to operation, including the output of the system, exposure time, and both real time and accumulated dose rates. With safety at the forefront of design, the user has continuous access to an emergency stop feature, and in the unlikely event communication is lost, the system will stop any exposure being carried out. The handset provides a simple and intuitive graphical interface along with a LED notification of the X-Ray status giving the user an easy reference point for the current system activity.

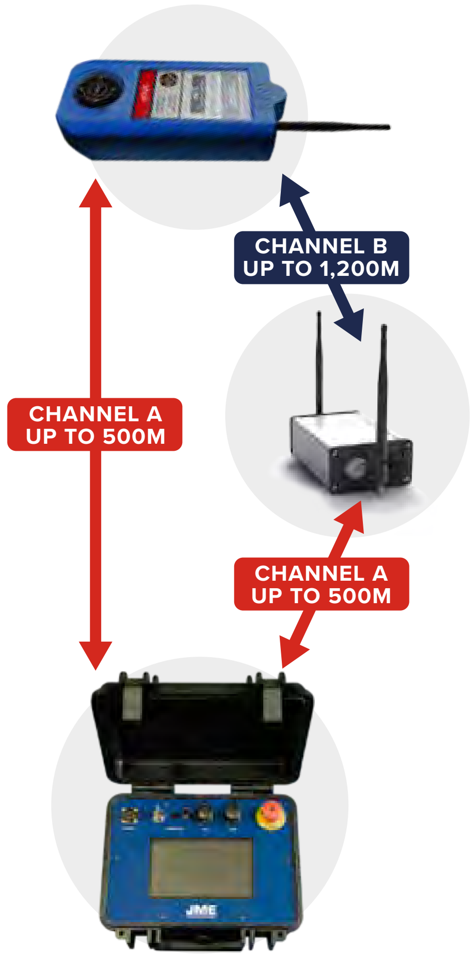
JME CONTROL PANEL

JME's New touchscreen control panel offers numerous improvements over the previous generation. It incorporates a data logging facility, allowing trained service personnel to interpret the historical parameters and usage of the unit. The built-in wireless connectivity allows connection to the handset, secured via 128 bit encryption, ensuring security of the system is maintained at all times. The user interface has been re-designed, making it more intuitive for the operator, there is also an increased amount of parameters which can be adjusted. Software updates are supplied by JME, these can be downloaded and installed via USB stick, ensuring the system remains futureproof.

JME RADIO REPEATER

JME's radio repeater increases the operating range of the radio link between the handset and control panel. Maintaining the secure 128 bit encryption, the radio repeater can increase the communication range by up to 1.2KM (To 1,7KM as standard). The Repeater can be attached to any ferromagnetic surface using the built-in magnet, the units are rechargeable and feature a long life lithium-ion battery.

DIRECT COMMUNICATION
– typical range up to 500m:



COMMUNICATION VIA REPEATER
– typical range up to 1,700m:

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