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Guidance

In-Service Inspection Guidance

Remote Visual Inspection

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1. Title

Guidance on the use of Remote Visual Inspection technology and with supporting results to supplement the thorough examination / inspection of various types of plant and equipment.

2. Scope

The use of new and emerging technology, in particular Remote Visual Inspection (RVI) is widely used throughout the field of engineering. The inclusion of this technology enables thorough examinations / inspections to be safely undertaken when unsafe, poor or no access can be established. The following procedure will outline the requirements and support the use of remote visual inspection to supplement thorough examinations / inspections.

3. Legislation

The following guidance can be used to facilitate thorough examinations / inspections within the following legislation:

- Lifting Operations and Lifting Equipment Regulations (LOLER) & Lifting Operations and Lifting Equipment Regulations (Northern Ireland) (LOLER (NI)).
- Pressure Safety System Regulations (PSSR).
- Provision and Use of Work Equipment Regulations (PUWER) & Provision and Use of Work Equipment Regulations (Northern Ireland) (PUWER).
- The Electricity at Work Regulations (EAWR).
- Control of Substances Hazardous to Health Regulations
- Control of Major Accident Hazards (COMAH).
- Working at Height Regulations 2005 (WAHR)
- S.I. No. 299 Safety, Health and Welfare at Work (General Application) Regulations.

As per the legislation outlined above, the following regulations specifically apply to the use of RVI.

3.1. Lifting Equipment

The Lifting Operations and Lifting Equipment Regulations (LOLER) and Lifting Operations and Lifting Equipment Regulations (Northern Ireland) (LOLER (NI)) Regulation 9, requires the thorough examination of lifting equipment by a Competent Person at periodicities defined by the regulation and given equipment state (installation, deterioration, repair, utilisation).

The Safety, Health and Welfare at Work (General Application) Regulations (as amended), Regulation 52, requires the thorough examination of lifting equipment by a competent person for lifting equipment and at periodicities defined by the regulation and within relevant parts of Schedule 1.

3.2. Pressure Systems - PSSR

Within Regulation 9, the Competent Person will carry out a thorough examination as per the scheme of examination ensuring safe continued use.

3.3. Work Equipment

The Provision and Use of Work Equipment Regulations (PUWER) and (PUWER (NI)), Regulation 6, requires the inspection of work equipment by a competent person, when exposed to conditions causing deterioration liable to result in dangerous situations.

The scope and periodicity of the inspection is dependent upon the complexity and risk profile of the work equipment.

The Safety, Health and Welfare at Work (General Application) Regulations (as amended), Regulation 30, requires the inspection of work equipment by a competent person, at the various stages of work equipment service life.

3.4. Electrical Equipment - EAWR

Regulation 4 of The Electricity at Work Regulations covers in a general way those aspects of electrical systems and equipment, and work on or near these, which are fundamental to electrical safety. The scope and periodicity of the inspection is dependent upon the complexity and risk profile of the electrical system.

3.5. Control of Substances Hazardous to Health Regulations

Regulation 9 of Control of Substances Hazardous to Health Regulations (COSHH) requires periodic thorough examination where the equipment is subject to deterioration due to use and where this deterioration could lead to employees being subjected to high levels of hazardous substances.

3.6. Control of Major Accident Hazards - COMAH

Due to the high risk, high profile equipment located on site. The use of RVI could be considered.

3.7. Working at Height Regulations

Regulation 12 of the WAHR requires an inspection of work equipment as per Regulation 6 of PUWER. The work equipment as detailed within Regulation 8 of WAHR includes; working platforms, scaffolding, personal fall protection equipment and ladders.

The Safety, Health and Welfare at Work (General Application) Regulations (as amended) Part 4 (Regulation 94 – 119) requires an inspection of working at height equipment at suitable intervals by a Competent Person. The working at height equipment as per Regulation 94 includes; ladders, personal fall protection systems, mobile platform and scaffolding.

4. Limitations

It may, however, be impractical to use RVI within the remit of thorough examination / inspection.

This may be due to factors such as:

- Practical considerations – unable to have sufficient lighting, contaminants present (dirt / dust / water).
- Clients request due to confidentiality issues.
- Safety concerns due to use of RVI and risk posed to the Competent Person.
- Impact to process safety (sparking to environment).
- Does this impact or pose a risk to the ES / CP due to use of RVI.
- Ability of RVI to identify the equipment is suitable and appropriate for the thorough examination / inspection.

5. Application of technology / Guidance

In the instance where RVI can be used to supplement the thorough examination / inspection, the Competent Person shall consider the following factors to ensure correct application and results can be obtained.

- Review scope of thorough examination / inspection and detailed understanding of acceptance criteria.
- It is accepted / not accepted that RVI can supplement the thorough examination / inspection.
- The chosen RVI method procedure and technique is appropriate for the use of thorough examination / inspection.
- The use of RVI is at the discretion and control of the Competent Person.
- The attendance of the Competent Person shall be necessitated by the Written Scheme of Examination / Scheme of Examination.
- The Competent Person must be in attendance to witness, direct and review the RVI process in real time ensuring compliance with the Written Scheme of Examination, Examination Scheme or Scope of Examination for the equipment.
- The Competent Person will review all results gained from RVI method and technique.
- This will be noted on the Report of thorough examination / inspection report.

6. Competence

RVI operation should be undertaken by a suitably trained, certified and competent operator.

7. Reporting

The RVI technique and method were completed on xx/xx/xx by _____. Details of report xxxxx dated xx/xx/xx and the results were verified as accurate and true.

Where certain Regulations require calibration / other instrumentation details, these shall be included on the report along with the details of the equipment used.

Note: The CP shall retain a copy of information / data supporting the result of a thorough examination / inspection.

UK and Ireland Appendices

Case Study 1

Remote Visual Inspection (RVI) of a Horizontal Multi-tubular Steam Boiler

Boiler Details:

Robey Lincoln,
Serial No. B65059 Manufactured 1974
S.O.L 100psi
Location – Cairo House, Oldham

Introduction

The boiler used for the trial had been out of use for several years and has been used for training of boiler inspectors. It was in good condition with few defects so some defects were simulated by drilling holes at various locations and cutting a slot through the shell to determine whether the remote inspection equipment was capable of finding them.

Two suppliers of remote visual inspection equipment were used in the trial but they provide different services so the results are not directly comparable.

Both suppliers visited the site before the trial to assess the dimensions, access available and what camera positioning equipment would be necessary.

Scope of trial

The trial was set up to demonstrate whether or not the remote visual equipment was capable of finding defects in the boiler, the ease of use, time taken for an examination and interpretation of images.

Results

Both sets of equipment were capable of resolving the simulated defects placed in the boiler. Whether the operator would or could have positioned the camera to find the defects without being directed to them was not determined. The memory card used to record the results of the second examination was defective and the test was not repeated as it would have been for a genuine plant examination so there are no photographic and video records of this.

Both operators had some difficulty positioning the cameras in the required locations, identifying the locations accurately and repeating the positioning for consistent results. At one point an inspector had to enter the boiler waterside to hold the camera in position.

Findings

- The overall examinations were significantly longer than a man entry examination with initial discussions, then to the positioning of the cameras in the required locations and then to confirm where they actually were. Some efficiencies can undoubtedly be gained with experience but it would still be a much longer process.
- When using flexible guide tubes the operator was unable to hold the scope steady due to the length of reach from the manway to the boiler tubeplate.
- An inspector would have to be present to direct the operator and interpret the results. The costs for an inspector's time would be around 3 or 4 times that taken for a man entry examination in addition to the costs of the operator and equipment.
- Dust from scale in the boiler caused problems on one lens which had to be withdrawn repeatedly for cleaning.
- Lighting is difficult as the camera lights shine directly on the surfaces. Normally an inspector will shine a torch beam along the surface to identify discontinuities, deflections and surface condition.
- Sizing of defects found is more difficult with RVI. A twin lens system for measuring the depth of defects did not give accurate results
- Cleaning of surfaces for examination is not possible with RVI. Waterside scale deposits and fireside soot deposits would normally be chipped or rubbed away by an inspector to examine the surfaces underneath
- The sense of touch is an important faculty for an inspector but is not available with RVI
- RVI is capable of accessing parts of the boiler which would not be accessible to the inspector, although this did not form part of the trial.

Conclusion

The nature of shell boilers make it a challenging environment for RVI. It could have some uses to supplement visual inspection of shell boilers when the design or size prevents internal access but the additional benefits in relation to the costs would need to be clarified.

For shell boilers that can be entered, using RVI as an alternative to man entry does have a number of disadvantages both in terms of its capability and cost. If the appropriate RVI equipment is selected, a suitable procedure is drawn up and a competent operator is used, then with guidance from a boiler inspector, it does have the capability to detect defects of a small (sub-critical) size. However there is a greater risk of defects being missed by RVI than by man entry. This is due to limitations with RVI; namely being unable to clean deposits from surfaces, manipulate the camera to completely cover all the surface areas under examination and to direct illumination to the optimum position. An evaluation of the criticality of defects likely to be missed should be considered before employing RVI.

Defects detected by RVI will need to be sized to determine criticality. As a result of limitations on accurate sizing with RVI, subcritical defects may end up being sentenced as critical as a result of the uncertainty.

In order for RVI to be successful then consideration would need to be made to adding RVI specific inspection openings to the boiler and/or building specific rigs which allows the camera head to be properly deployed in the relevant areas within the boiler. A change to RVI as the means of examination would necessitate a change to the written scheme of examination.

Case Study 2

Remote visual inspection (RVI) of static storage tank

Stainless Steel Storage Tank

Introduction

A trial was carried out on a flat bottomed static storage tank using RVI equipment. Unlike previous blind trials the camera operator was given a drawing of the tank and supplied photos from the previous inspection. The tank is manufactured from 316L stainless steel and was located in a bund. The camera supplier/operator came with sufficient equipment to carry out the full examination, but due to time constraints a complete examination was not possible. However the main purpose of the trial was to demonstrate RVI capabilities.

Examination

The camera was fixed to the lower manway for the purpose of this test. (See Figure 6). In order to complete a full examination of the tank it would have been necessary to move the camera to the upper manway. From the lower position it was possible to examine (eventually) the upper nozzle attachments which were approximately 3.5 m above the camera entry point and also the attachments for the fill line (2.5 m above). The camera operators were untrained site staff and followed the camera supplier's basic instructions before use. Skill levels increased throughout the trial and the images produced were of very good quality.

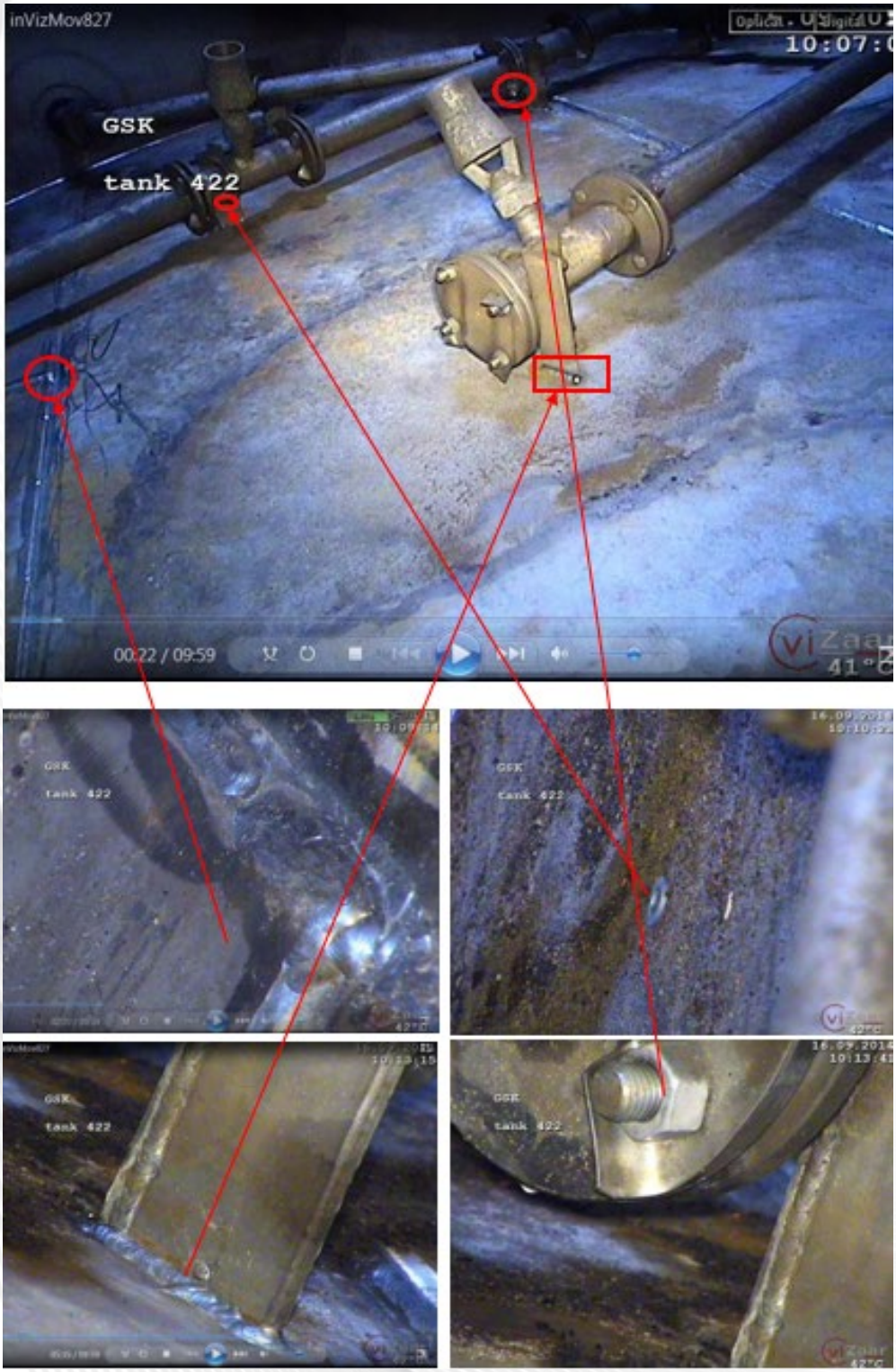
Results

Whilst the trial was successful, there are still some issues to be resolved:-

1. In order to complete a full visual examination of the tank it is clearly going to be necessary to adjust the camera position a few times.
2. The video footage produced was of fair quality but could have been improved by covering the upper manway opening in order to achieve better contrast.
3. The tank would still need to be cleaned, probably more effectively than for man entry.
4. Examination of the tank floor remains an issue, particularly in the case of carbon steel tanks where the probability of corrosion from the underside needs to be addressed.
5. Checking the floor for settlement or lifting. This could possibly be assessed by flooding the lower parts of the tank with water to highlight high/low points.

Top View 1

Top View 2


inVizMov827
GSK
tank 422
00:22 / 09:59

Conclusion

The results have indicated that with more time and a little more development of the operator's skill in using the equipment, it may be possible to use this technique for visual examination for this type of vessel. It would probably not replace man entry entirely but may make it possible to extend the interval between a full man entries where this technique is used at an interim examination.

Considered Improvements:

1. Blank off the stray light coming from the upper manway.
2. Use the upper manway as a second camera mounting point.
3. Operator training in the use and functions of the camera as only basic functions were used during this trial.

Case Study 3

CCTV Mast with anti-climbing feature.

The mast requires inspection but cannot be climbed due to the anti-climbing device around it. Due to the location a MEWP is not feasible. Use of Remote Visual Inspection techniques allowed close up inspection of the structure and fixings. The inspection was recorded throughout in HD and still images were taken.

Case Study 4

Inaccessible roof with an LEV fan on it. System performance was poor and from beneath it was apparent there was an issue with the ducting. Use of Remote Visual Inspection techniques revealed that the fan had fallen from its mounting.