SAFED

SAFETY ASSESSMENT FEDERATION

Guidance

In-Service Guidance

Guidance on the use of drone technology and data to support thorough examination / inspection of various types of plant and equipment.

REFERENCE: D 001
ISSUE: 02
DATE: 17/11/2021

DOCUMENT INFORMATION:	
REFERENCE:	D 001
ISSUE:	02
DATE:	17/11/2021
PREPARED BY:	Emerging Technology TC 10
APPROVED BY:	TSC

DOCUMENT HISTORY RECORD:

ISSUE:	DATE:	CHANGE DETAIL:
01	16/07/2021	Initial Document
02	17/11/2021	Document Review

CONTENTS

1. Title

Guidance on the use of drone technology and data to support thorough examination / inspection of various types of plant and equipment.

Definition:

Drone – for the purpose of this guidance, a drone is regarded as an Unmanned Aerial Vehicle (UAV).

2. Introduction

The purpose of the document is to guide the Competent Person in the application of drone technologies enabling the completion of the thorough examination / inspection.

Application of such technologies should be considered in circumstances where:

- A safe means of access to critical parts and/or safety devices is not available, by suitable and satisfactory means, and/or
- The detail obtained will enhance the findings of the thorough examination / inspection.
- The total operational impact is justified.

3. Scope

Where consideration is being given to the use of remote visual technology, such as Drones, in the completion of the thorough examination / inspection then a benchmark condition of the equipment should be ascertained, via;

- Previous detailed scrutiny, and / or
- Suitable and sufficient documentation supporting the installation, service life usage and repair history, and / or
- Suitable and sufficient supplier / installer test data.

The use of 'Drones' would be most applicable in the assessment of;

- Structural members, joints and weldments.

- Mechanical assembly stability and security.
- Mechanical component condition and security.

Primarily, technology such as drones, would be employed to supplement the thorough examination / inspection. A degree of tactile scrutiny of the equipment in question would be required to support / verify the drone findings and vice versa.

4. 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 (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 drones.

4.1. 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.

4.2. 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.

4.3. 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.

4.4. 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.

4.5. 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.

4.6. Control of Major Accident Hazards - COMAH

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

4.7. 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.

5. Limitations

A number of factors may need to be addressed before consideration is given to the use of drones, in support of the thorough examination / inspection.

- Practical considerations – interference with external sources or contaminants present (dirt / dust / water).
- Clients request due to confidentiality issues.
- Sites and/or specific location areas may have security restrictions, prohibiting the use of such technology.
- Flight authorisations may be required to permit drone operation. Restrictions may be in place, for operations overpopulated areas, requiring planning (exact time/duration) and/or safety preparation (temporary cordoning off, for pedestrian/vehicle access).
- Is the use of drones appropriate or can a reasonably practicable and safe means of access be provided.
- The client should be suitably advised of the intention to use drone technology, in support of their thorough examination / inspection. The scope of activity and issues which may result if this is deemed as the only reasonably practicable and safe means of completing a thorough examination may need to be justified.
- The Competent Person carrying out the thorough examination / inspection should satisfy themselves that the detail they will obtain from the drone output is sufficient for them to complete a thorough examination / inspection and report accordingly.

NOTE:

At present, the drone technology available is not deemed suitable for the full functional assessment of drive train and mechanical machinery assemblies. As technology develops this will be continually reviewed.

6. Application of technology / Guidance

In the instance where drone technology 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 drone use can supplement the thorough examination / inspection.
- The chosen drone method procedure and technique is appropriate for the use of thorough examination / inspection.
- The drone use is at the discretion and control of the Competent Person. If the drone method and results are to ascertain a high risk / high severity issue the Competent Person may request to be on site during the drone thorough examination / inspection.
- The attendance of the Competent Person shall be necessitated by the Written Scheme of Examination / Scheme of Examination.
- The Competent Person will review all results gained from drone technology examination / inspection method and technique.
- This will be noted on the report of thorough examination / inspection report.

The Competent Person carrying out the thorough examination / inspection will in the absence of a Written Scheme / Examination Scheme define the scope of the examination / inspection. They will identify the critical areas of the item of equipment they cannot access and direct attention to those areas, in order to obtain suitable and sufficient detail to ascertain the presence of any evident defects.

The Competent Person shall satisfy themselves of the detail obtained from the drone output and that it confirms the integrity of the equipment. Should further evidence / information be required, further measures should be subsequently requested.

7. Competence

Drone operation and output recording should be undertaken by a suitably trained, certified and competent operator.

8. Reporting

The drone 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.

9. UK and Ireland Appendices

Case Study 1

Case Study for use of Drones in supporting the thorough examination of a Runway Track / Overhead crane tracks.

The site contained a number of runway tracks and overhead crane tracks that were problematical in gaining access. They are either too high for the use of a ladder, over water, or access obstructed by other machinery.

The use of a MEWP was considered but did not provide full access due to obstructions and limited access.

It is possible to construct scaffolding enabling full access for every 12 monthly examination but this is extremely expensive, and disruptive, so other solutions were sought.

At the initial accessed examination bolts and nuts were marked with contrasting paint to assist in monitoring any movement remotely.

An examination scheme was developed which required an annual supplementary examination using a drone, with a thorough, accessed examination at three years. If no deterioration is noted during the three-year cycle consideration is given to extending the period between accessed examinations to five years. The supplementary examination procedure details the parts subject to drone examination and includes a full inspection from ground level.

The supplementary drone examination is completed with the competent person, on site, monitoring a slave screen, directing the drone pilot as required. A full video record of the examination can be downloaded and saved for reference.

Case Study 2

Introduction

Equipment: Internal Atrium Rail Inspection

PPE Requirements for the use of such technology:

- Safety helmet – due to potential falling object hazard during drone operation.
- Safety glasses – due to dust dispersal by drone rotors.
- Ear defenders – due to noise when internal working.
- Safety shoes – due to potential falling object hazard.

The initial intention was to assess the atrium rails, from a health and safety perspective, in order to ascertain as far as is reasonably practicable their integrity, prior to their use for access to inspect.

Discussing the process to be undertaken with the client contact, we were advised that the rails are used for abseiling and no Boatswain's Chair was available or indeed had seemingly ever been provided. This altered the scope of activity significantly, as we do not permit our Engineer Surveyors to abseil, due to the process being deemed an extremely high hazard.

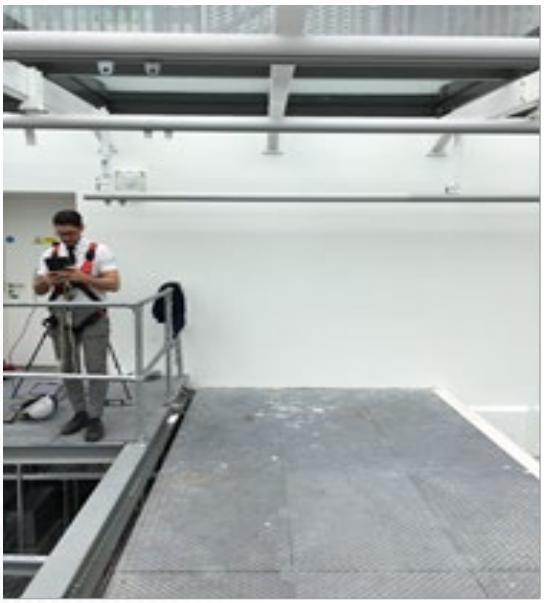
The rail markings stated EN795 build, 1 Person capacity via a main rail carriage attachment point and Shock Absorber use via a second independent rail carriage attachment point. This would tend to suggest that impact loading is anticipated during use and hence abseil operation is not an unreasonable assumption.

The maintenance service provider tags the individual rails as Abseil Rails.

The client contact was asked to confirm this and was advised that the O&M would be the first port of call.

Therefore, the scope of activity was revised, as follows:

- The rigging platform area would be used to make a sample assessment for the fixings which were accessible for close tactile scrutiny.



- The client would load test the rail annually, in order to confirm mechanical and structural load bearing integrity which could not be ascertained by mere visual scrutiny.

Application

The access difficulties at the upper atrium level which could potentially have resulted in entrapment of the drone were discussed. A flight path was chosen which both ensured the detail necessary was observed and minimised the potential for drone entrapment.

The drone was used to provide visual evidence of the critical elements of the rail assemblies:

- Upper hanger fastening bolts/nuts.
- Lower hanger rail stud/nut and hanging ‘T’ blocks.
- Rail section jointing plate and fasteners.
- Critical welds.

Certain of these assembly elements would have been inaccessible, had the inspection been carried out in an abseil configuration.

The drone could be readily manoeuvred into locations which enabled the critical elements to be displayed and filmed. Image quality was very good on the monitor. Points of Interest (POI’s) could be individually recorded and the full flight filmed. These records could then be appended to the given item.

Conclusion

The drone could be readily manoeuvred into locations which enabled inaccessible critical elements to be displayed and filmed.

Points of Interest (POI's) could be individually recorded and the full flight filmed.

The technology could supplement those inspections where access by an Engineer Surveyor is both unsafe and/or physically inaccessible. In certain circumstances this could enhance the equipment scrutiny data, due to manoeuvrability into areas which would not normally be accessible.

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.

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.

Case Study 5

Initial Trial – UAV Thorough Examination of Internal Crane Tracks

Introduction

A client site was made available for the purpose of initial testing for the application of Unmanned Aerial Systems (Drones) for supplementing Thorough Examination of high-level lifting plant where access is restricted or hazardous for conventional, tactile examination. The site featured multiple Electric Overhead Travelling Cranes, Crane Tracks and Gantry Structures.

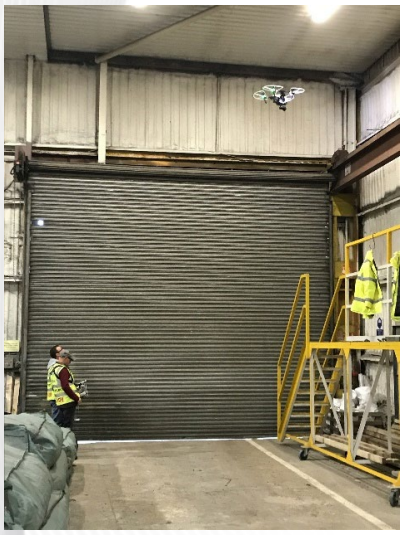
The goals were to gain understanding of the following points;

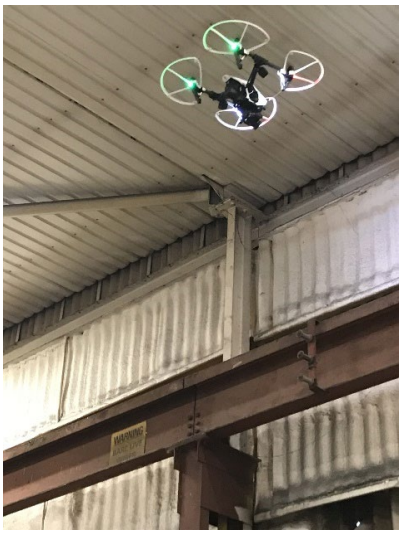
- Quality of imagery (RGB stills and video) during & post flight.
- Limitations/restrictions of data capture.
- Practicalities of drone usage.
- Comparison against conventional tactile examination (quality & time taken).
- Pro's / Con's for Competent Person/Inspection Body & Client.

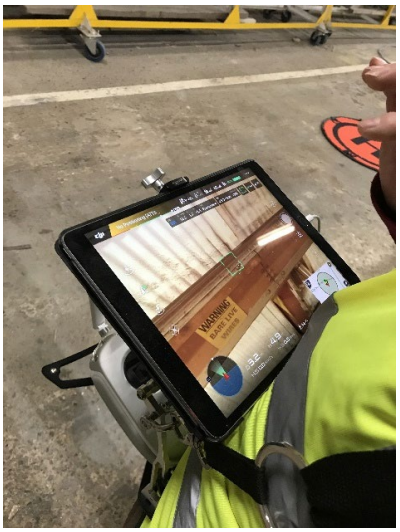
Scope of trial

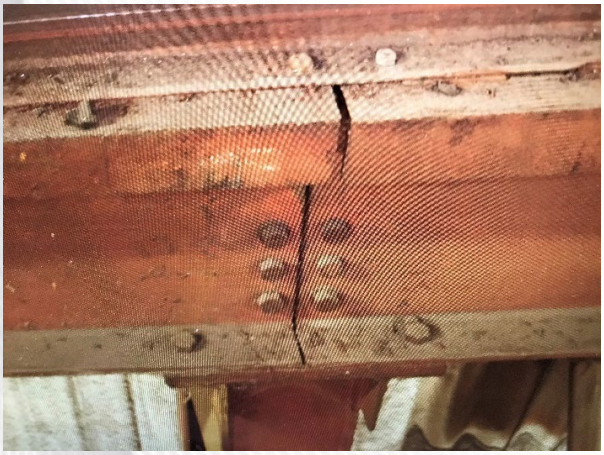
Conventional examinations are possible at this site through a variety of Mobile Elevating Work Platform, Man-Cage and Ladder access due to client's footprint of machinery which proves time consuming with varying levels of acceptable risk (within RAMS) to Engineer Surveyor (ES). ES had conducted Thorough Examinations (TE's) recently so was familiar with plant and site.

Imagery capture was provided by a service provider with the intention to utilise two different drones. Unfortunately, the smaller platform space-frame cage did not arrive in time so only the larger platform was used. Pre-visit survey was conducted by ES with all relevant info and site images compiled and information supplied to service provider. Point of Work Risk Assessment was conducted by ES and agreed by H&S Manager, Client and Drone Operator. The largest crane tracks were selected for initial testing due having the least obstructions and no thoroughfare easing control of entry.









- Dust and debris were immediately disturbed by downwash of drone.
- Drone lighting pods were essential to image quality.
- Larger drone (DJI Inspire) was too big for internal flight – too much disturbed air especially when in close proximity to ceiling and wall – whilst testing field of view of upper inspection surfaces, the lower pressure above propellers caused un-commanded altitude increase and drone impact with ceiling. Control was recovered and drone landed safely but with damage. Smaller, caged drone to be used at next internal/close proximity test.

- Video footage unstable and not deemed of much benefit if only for position reference.
- Images of high quality with zoom capability very useful.
- Torque reference for attached hardware required e.g. witness marks.

Considerations when using Drones

- Control of access of inspection area.
- Potential for extra permissions e.g. external flights in restricted airspace or proximity to people/roads/structures.
- Limited field of view e.g. outboard bolts, upper surfaces, welds etc.
- Light/weather conditions.
- Only able to locate missing/very loose/unseated attachment hardware – witness marking/visible aid essential.
- Client unsure of new tech usage – does not appear a mainstream solution but more where access is restricted/client access costs are high/operational downtime impacted for long conventional examination. Any 'need' for drone use appears more with client.
- Caged drone for close proximity required. Drone suitability is therefore essential.
- Experienced operator essential.
- Secondary camera operator essential for uncaged drone.
- Time consuming image analysis.

Conclusion

Drones are a supplementary aid – not a replacement to conventional examinations.

- Plant may need modifying with visual aids (torque witness marks / torque indicating bolts).
- Investigate viability of benchmark conventional inspection with supplementary periodic drone inspections.
- Limited to fixed, static plant at present.
- Client need/benefit appears driving factor.
- Experienced operator and correct equipment selection essential.

Case Study 6

Remote visual inspection (RVI) of static 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.

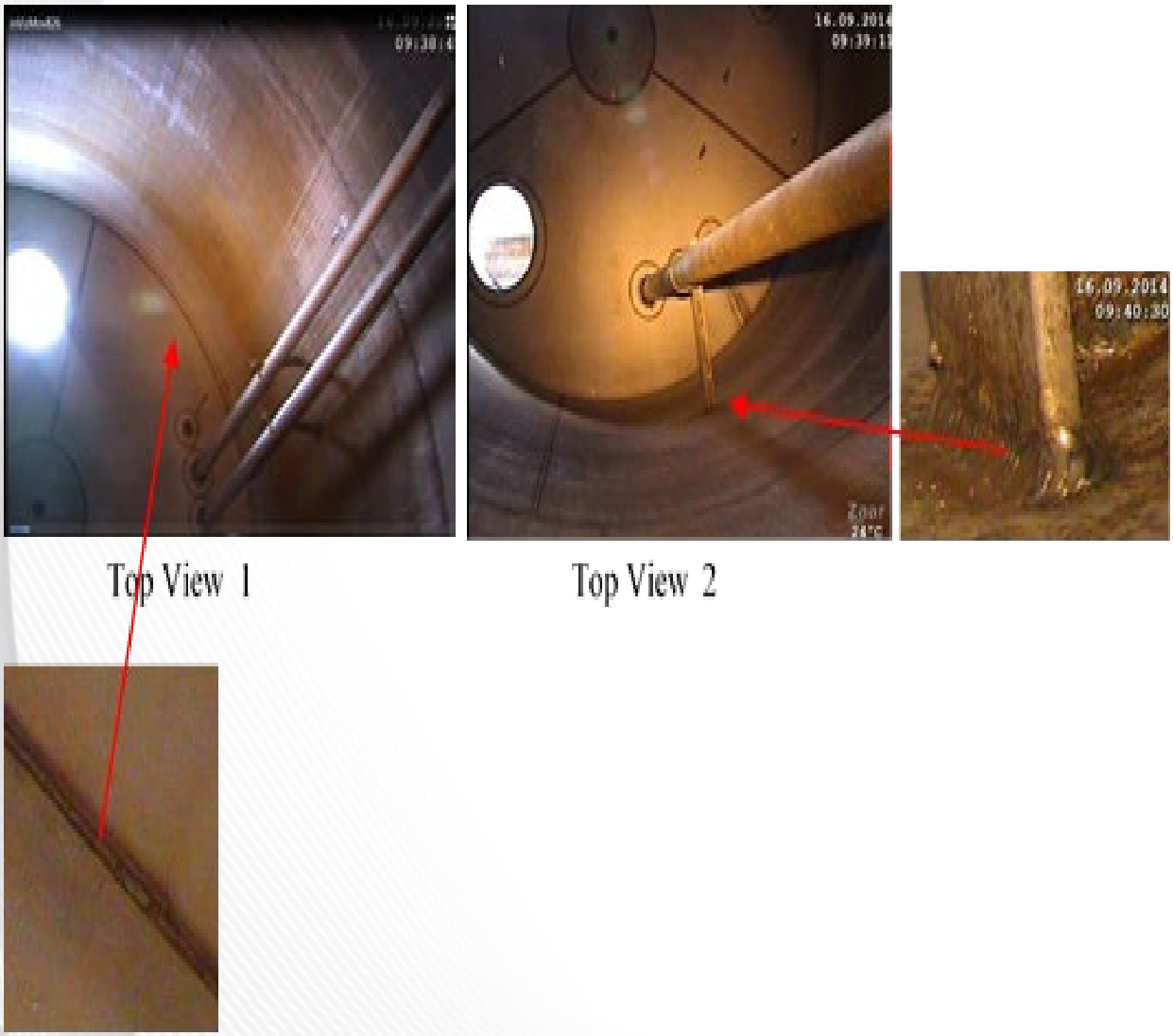
Examination

The camera was fixed to the lower manway for the purpose of this test. (See Figure 1). 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.

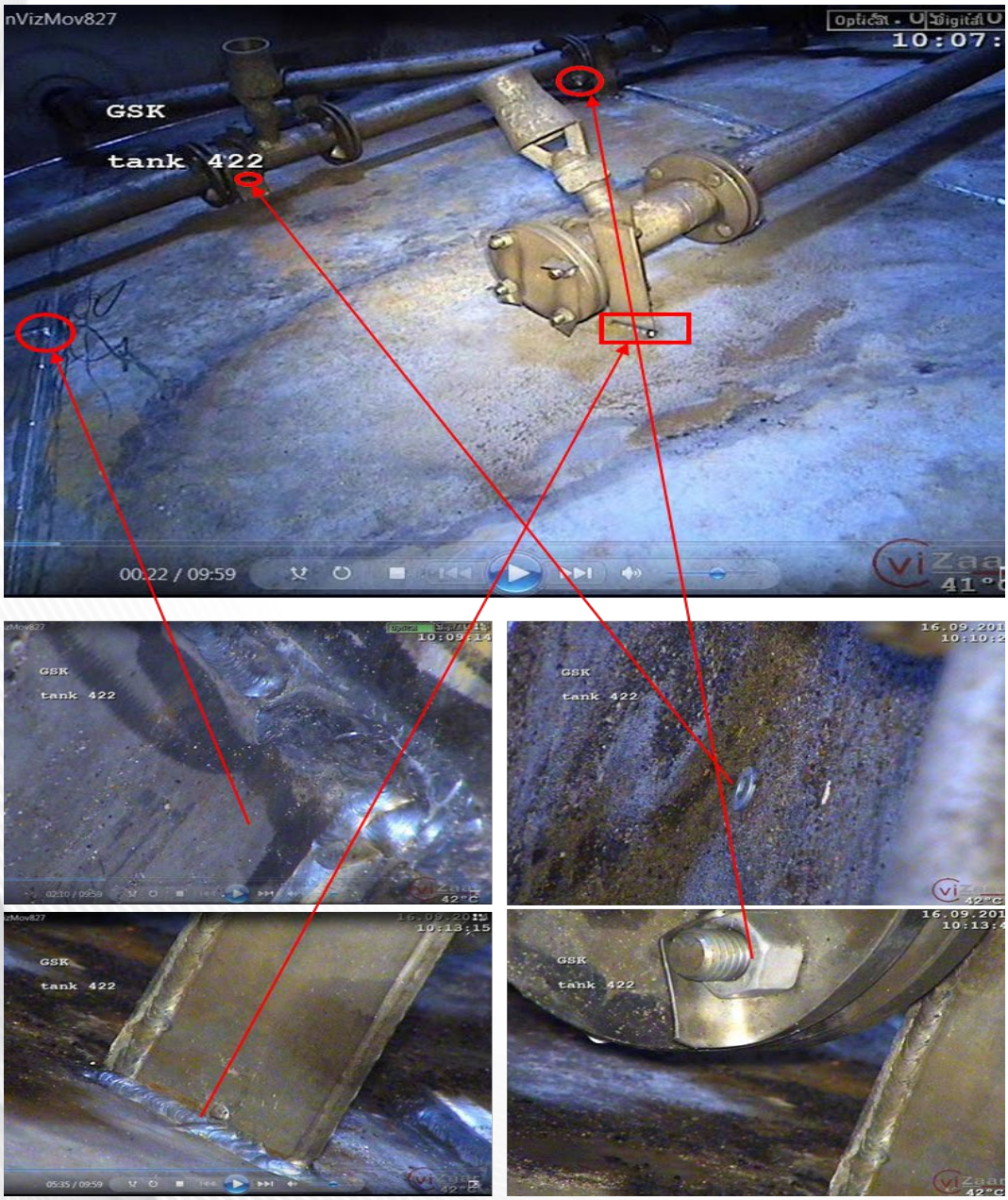
Results

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.



Images of Upper Surfaces and Tank Walls.
Note the camera remains fixed to the lower manway.



General View of Floor

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 entry 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.