



PROJECT ASSESSMENT REPORT			
Unique Document ID and Revision No:	ONR-CNRP-PAR-14-032 Revision 0	TRIM Ref:	2015/112518
Project:	Preliminary Investigation into the CO ₂ Release at Heysham 1		
Site:	Heysham 1		
Title:	Basis of enforcement decision following preliminary investigation into CO ₂ release at Heysham 1.		
Licence Instrument No: (if applicable)	N/A		
Nuclear Site Licence No:	60		
Licence Condition:	LC28		

Document Acceptance and Approval for Issue / Publication

Role	Name	Position	Signature	Date
Author	[Redacted]	Nominated Site Inspector		23 March 2015
Reviewer	[Redacted]	Superintending Inspector		24 March 2015
Accepted by ¹	[Redacted]	Head of Operating Reactors Sub-Programme		24 March 2015
Approval for publication ²		Head of Operating Reactors Sub-Programme		

Revision History

Revision	Date	Author(s)	Reviewed By	Accepted By	Description of Change
A	23 March 2015			n/a	1 st draft for SS review
0	24 March 2015				First accepted issue

¹ Acceptance of the PAR to allow release of LI

² Approval is for publication on ONR web-site, after redaction where relevant

Circulation (latest issue)

Organisation	Name	Date
Office for Nuclear Regulation	[REDACTED]	
Environment Agency	[REDACTED]	
Licensee	[REDACTED]	

OFFICIAL

**Basis of enforcement decision following preliminary investigation into CO2 release at
Heysham 1**

Project Assessment Report ONR-CNRP.-PAR-14-032
Revision 0
24 March 2015

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Published 03/15

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EXECUTIVE SUMMARY

This Project Assessment Report (PAR) details the Office for Nuclear Regulation's (ONR's) basis for the enforcement decision taken following an incident involving a failed high pressure Carbon Dioxide (CO₂) pipe on the East CO₂ Storage Plant at Heysham 1 power station, and the related Licence Condition (LC) inspection findings from the subsequent preliminary investigation.

Background

At 00:21 on 16 March 2015 Heysham 1 Power Station declared a site incident following the detection of a leak from the East CO₂ storage plant.

The leak resulted from the failure of a 3-inch diameter pipe section between the High Pressure (HP) CO₂ storage tank and the Pressure Sustaining Unit (PSU) which resulted in approximately 40 tonnes of CO₂ being directly released to the atmosphere. The plant was not in service to support reactor operation because it had been offline for approximately eight months previously to enable maintenance and inspection work to be undertaken. The plant was in the process of being re-commissioned when the incident occurred.

The site muster for both Heysham 1 (42 people) and Heysham 2 (223 people due to the outage) was completed successfully. All staff were accounted for in the muster. Although no one was injured as a result of this release, given the significance of this event and the potential consequences, the decision was made to undertake a preliminary investigation into the circumstances of the event to inform any potential regulatory action.

Assessment and inspection work carried out by ONR in consideration of this request

A preliminary inspection was launched in response to the notification received regarding the failed pipework. The conclusions drawn from the intervention report identified significant shortfalls against the requirements of LC28 relating to examination, inspection, maintenance and testing. This judgement was further supported by several existing issues raised against the licensee regarding non-compliance against LC28 expectations and adequacy of arrangements for Pressure Systems Safety Regulations 2000 (PSSR).

Matters arising from ONR's work

Information gathered during the preliminary investigation has identified that the licensee has previously been aware of corrosion and degradation mechanisms affecting the CO₂ plant pipework and have taken action to remediate the pipework affected. ONR has reviewed this information and could find no evidence to demonstrate that the pipework has been inspected since 2006. The absence of any entry relating to CO₂ storage plant pipework on the maintenance schedules has prompted concern from ONR, especially when considering historic reports produced by the licensee that identify this as a shortfall and make recommendations to include it on the maintenance schedule.

ONR considers the consequences of this failure to have significance with respect to the potential for personal injury and nuclear safety. The incident did not result in any case of personal injury, nor did it warrant action to trip either of the reactors on site. However, ONR judges that this is mostly as a result of the incident occurring during the night. During a normal, operating day, ONR inspectors observed several working parties in close proximity to the breach location, some of which were working on scaffolds and near trenches. ONR judges that the possibility of injury occurring during normal working hours to have been likely, given the extent of the resultant CO₂ cloud and associated toxicity/asphyxiating properties.

Basis for enforcement decision

ONR has used its Enforcement Management Model (EMM) to judge the appropriate enforcement action to take in response to this incident and considers the issue of an Improvement Notice is needed to secure compliance with the law.

ONR considers this course of action to be appropriate by taking cognisance of the following factors:

- The licensee has a previous history of similar incidents occurring across the EDF reactor fleet. This has resulted in issues being raised by ONR related to LC28 compliance and PSSR compliance.
- The potential risk associated with the failure from a personal injury and nuclear safety perspective.
- The licensee was aware of the issues identified and has not made adequate progress to address them.

Conclusions

From the documents provided by the licensee and the information gathered through discussion with licensee staff and nominated competent persons, ONR considers there to be a significant shortfall against the requirements of LC28, and judges the licensee's arrangements for examination, inspection, maintenance and testing of the CO₂ pipe on the East CO₂ plant to be unacceptable. ONR consider these shortfalls are likely to have contributed to the incident, resulting in the loss of approximately 40 tonnes of clean CO₂ from a plant that has an associated nuclear safety function.

ONR's judgement is supported by previous incidents both at Heysham 1 site and across the EDF reactor fleet that demonstrate the licensee was aware of the potential for plant failures of this nature. This is further enhanced by the information provided that indicates the licensee was aware of such issues but had not acted to fully control the risks. Recommendations made by the licensee's own internal inspection reports issued in December 2010 identified the requirement to include the CO₂ storage plant pipework on the maintenance schedule, which again, ONR could find no evidence of implementation or reasons for dismissal.

Recommendation

This project assessment report recommends that ONR should issue an Improvement Notice for contraventions under Health and Safety at Work Act 1974 (HSWA), s2(1) and s3(1), the Management of Health and Safety Regulations (1999) Regulation 5(1) and the most appropriate Licence Condition - LC28.

ONR should conduct a full investigation to determine the cause of the failure and identify if further regulatory action is required to secure improvement.

LIST OF ABBREVIATIONS

CO ₂	Carbon Dioxide
CNC	Civil Nuclear Constabulary
CUI	Corrosion Under Insulation
EC	Engineering Change
EMM	Enforcement Management Model
HOW2	(Office for Nuclear Regulation) Business Management System
HP	High Pressure
HSW	Health and Safety at Work Act 1974
IFDF	Irradiated Fuel Disposal Facility
LC	Licence Condition
MEVL	Mandatory Evaluation
NGL	EDF Energy Nuclear Generation Limited
ONR	Office for Nuclear Regulation
PAR	Project Assessment Report
PICA	PSR Identified Corrective Action
PSSR	Pressure Systems Safety Regulations 2000
PSR2	Periodic Safety Review 2
PSU	Pressure Sustaining Unit
RGP	Relevant Good Practice
SAP	Safety Assessment Principle(s)
SSC	Structure, System and Component
TAG	Technical Assessment Guide (ONR)
TSD	Tertiary Shutdown
WSE	Written Scheme of Examination

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1 BACKGROUND

1. At 00:21 on 16 March 2015 Heysham 1 Power Station declared a site incident following the detection of a leak from the East Carbon Dioxide (CO₂) storage plant.
2. The leak was caused by a 3 inch diameter pipe failure in a pipe section between the High Pressure (HP) storage tank and the Pressure Sustaining Unit (PSU) which resulted in approximately 40 tonne of CO₂ being directly released to the atmosphere (See figures 1 and 2). The plant had been out of service for approximately eight months previously to enable maintenance and inspection work to be undertaken. The plant was in the process of being re-commissioned and had been re-pressurised as part of re-commissioning when the incident occurred.
3. The site muster for both Heysham 1 (42 people) and Heysham 2 (223 people due to the outage) was completed successfully. All staff were accounted for in the muster.
4. Although no one was injured as a result of this release, given the significance of this event and the potential consequences, the decision was made to undertake a preliminary investigation into the circumstances of the event to inform any potential regulatory action.
5. The preliminary investigation was undertaken on the 17 and 18 March 2015 by the nominated site inspector and two structural integrity inspectors. This report presents the initial findings from the investigation and the basis for enforcement action at Heysham 1. The results of formal application of the Enforcement Management Model (EMM) in accordance with the relevant ONR guidance (Ref. 1) and the ONR Enforcement Policy Statement (Ref. 2).

2 ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR RELATED TO THE INCIDENT.

2.1.1 HEYSHAM 1 CO₂ STORAGE PLANT SYSTEM BASED INSPECTION (SBI)

6. ONR conducted a planned SBI on the CO₂ storage and distribution systems at Heysham 1 power station in June 2014 (Ref. 3). Multiple LCs were inspected and judged to be adequate, however, the structural integrity inspector leading the site inspection identified a shortfall in the licensee's arrangements for LC28, examination, inspection, maintenance and testing of the CO₂ storage plant pipework.
7. This shortfall was identified in the station maintenance schedule, which did not have an entry for pipework on the CO₂ storage plant. This is in contrast to the CO₂ distribution pipework (which carries the CO₂ gas from the storage plant to the reactor) which is listed as an item on the maintenance schedule. This issue was recorded by ONR and raised on the ONR issues database as issue number 2814. The licensee recognised this shortfall and raised a commitment to have the pipework added to the maintenance schedule (licensee reference action request AR00890266). This required an engineering change (EC) document to be produced, which at the time of the incident had not been completed.

2.1.2 PRESSURE SYSTEMS SAFETY REGULATIONS (PSSR) COMPLIANCE

8. ONR has previously written to EDF (Ref. 4) relating to compliance with PSSR inspections following a catastrophic failure of 8" steam pipework at Heysham 1 and missed maintenance inspections at Sizewell B. In addition ONR has previously raised a corporate issue relating to the overall reliance on PSSR inspections to satisfy the requirements of LC28 (issue 2333) which resulted in the requirement for EDF to conduct an investigation to determine if there are any systemic weaknesses in their

arrangements for compliance with PSSR and for systems where both PSSR and LC28 apply, examinations are co-ordinated where appropriate. A fleet wide Mandatory Evaluation (MEVL) has been produced and rolled out to all sites and the licensee are due to provide an update on progress for this issue in April 2015.

2.1.3 PRELIMINARY INVESTIGATION FOLLOWING THE EAST CO₂ STORAGE PLANT PIPE FAILURE INCIDENT

9. ONR has completed a reactive, unplanned inspection in response to the declaration of a site incident by Heysham 1 (Ref. 4). The purpose of the intervention was to conduct a preliminary investigation the objectives of which were to:

- collect information and records related to the East CO₂ plant, particularly with respect to examination, inspection, maintenance and testing in accordance with LC28 compliance and PSSR;
- make a judgement as to the adequacy of the statement provided by the licensee that the West CO₂ storage plant is suitable for continued service.

10. The outcome of the preliminary inspection team concluded:

- The licensee's arrangements for compliance LC28 were unacceptable for the pipework on the East CO₂ storage plant. Progress made by the licensee in conjunction with the ONR issue raised following the SBI (eight months before the incident occurred) was inadequate.
- The licensee has identified degradation of this pipework to be an issue during the last Periodic Safety Review (PSR2) and took action to improve the general condition of both plants. No evidence has been provided to show that the pipework has been inspected, with some reports suggesting that the last time the lagging was removed on the failed pipe could have been as long ago as 2006. Recommendations were made by the licensee to improve the pipe hanger and lagging design to minimise water ingress and add the pipework onto the maintenance schedule.
- Improvements could be made to the PSSR inspection and reporting logs to identify which samples of pipework are selected for inspection, why they were selected and when they were last sampled.

3 MATTERS ARISING FROM ONR'S WORK

3.1 REVIEW OF RISK FACTORS

11. ONR consider it important to identify the risks associated with this incident from a personal injury and nuclear safety perspective.

3.1.1 IMMEDIATE RISK OF SERIOUS PERSONAL INJURY

12. On receipt of notification of this event the site inspector sought justification from Heysham 1 on continued safe operation of the West CO₂ plant and hence the two reactors. This was provided verbally followed up by a written response. The inspection team also conducted a walk down of the West CO₂ plant with station staff as part of the preliminary investigation. ONR judged that there was no immediate requirement to seek shut down of the West CO₂ plant. Notwithstanding this, as a result of the walk down and ONR comments the licensee is conducting a number of external radiographs on a number of pipe sections.

13. An e-mail was also sent to the other stations requesting justification for operation of their CO₂ plants in light of this event.

3.1.2 POTENTIAL RISK FOR SERIOUS PERSONAL INJURY

14. Currently electrical work is being undertaken next to the East CO₂ plant to upgrade the Heysham 2 400KV cables and associated transformers. At the time of the event a number of staff were working a couple of hundred meters away from the release site in the opposite direction to the wind. In addition there were at least two members of the Civil Nuclear Constabulary situated in a static vehicle within 50 metres of the release site, again, downwind of the release site but in close proximity.
15. At 09:00 on 18 March 2015 the site inspector viewed the area around the breach site and observed half a dozen people working within five meters of the breach site in a fenced off area on uneven ground. In addition, there were at least 15-20 people working on the other side of the road on the transformers both on the ground and operating a large crane.
16. The main access/ingress route from Heysham 2 to Heysham 1 is via a pass controlled barrier at the far-east side of the East CO₂ plant approximately 8-10 meters from the release site (This is highlighted on Fig 2). This was also engulfed by the CO₂ vapour cloud.
17. Given the extent and speed of the CO₂ release it is ONR's judgement that if this event had occurred during the day, it is **probable** that there would have been **serious personal injury** to a number of these workers and probably fatal injuries from asphyxiation and/or from the toxicity of the CO₂. In addition, if the wind was blowing in the opposite direction, this could have seriously affected both the CNC and the half dozen or so staff working further upstream of the release.

3.1.3 BENCHMARK RISK

18. Given the potential consequences of CO₂ is serious personal injury, the benchmark likelihood if EDF complied with the law would be nil or negligible.

3.1.4 RISK GAP

19. As this event has the potential for multiple casualties I have used table 2.2 in the EMM which, using the above, results in an extreme risk gap.

3.2 APPROPRIATE STANDARD

20. The CO₂ storage system comprises of an East and West plant with the latter being the newer plant. The purpose of the CO₂ plant is to maintain the volume of CO₂ used to cool the reactor by "topping up" the CO₂ in the primary circuit. The CO₂ plant also provides the required quantities of CO₂ in the event of a depressurisation event and is required for the Tertiary Shutdown (TSD) system, used to enable boron beads to be injected into the reactor to hold down reactivity. It also provides a safety function for the Irradiated Fuel Dismantling Facility (IFDF) in accident conditions. Either plant can provide these requirements independently. CO₂ availability (volume and pressure) is a safety case (tech spec) requirement which necessitates reactor shutdown if the required quantities of CO₂ are not available.
21. I therefore consider that the CO₂ storage system provides a system important to nuclear safety and therefore clearly needs to be maintained in accordance with LC28.

The CO₂ storage system also constitutes a pressure system under PSSR.

3.3 INITIAL ENFORCEMENT EXPECTATION

22. Using table 2.1 of the EMM for health and safety risks; an extreme risk against a defined standard results in an initial enforcement expectation of **Improvement Notice** to secure compliance with the law with the **consideration of prosecution**. See attached EMM1.

3.3.1 BASIS OF IMPROVEMENT NOTICE

23. The findings from the preliminary investigation indicate that this section of the pipework does not appear to have been inspected since 2006. ONR has previously carried out a system based inspection of the CO₂ system in June 2014 (2014/249519) and raised an issue asking for evidence that this pipework is subject to adequate maintenance under LC28. At the time of this inspection there was no indication that this section of pipework was unsafe and that immediate action was required. This action is still open.
24. The pipe failure is believed to be as result of corrosion under insulation (CUI) however this has yet to be confirmed. Degradation of the CO₂ plant pipework due to CUI had been identified during PSR2 as a known issue on the East and West CO₂ plants. A PSR Identified Corrective Action (PICA) item (4184) was raised for the site to conduct a full review, refurbish and repair programme to address concerns over fitness for duty (reference HYA/M/SSR/109 August 2011). During this programme, the section of failed pipe was identified in 2009 to have been inspected in 2006 and rated as 'good' and not to be inspected or replaced.
25. A later CO₂ System Safety Review issued in April 2014 (HYA/M/SSR/168 Rev 0) claims that extensive pipework corrosion issues associated with water ingress into lagging on the on the CO₂ plants has been addressed under the PSR2 CO₂ plant PICA remediation project. Information gathered during the preliminary inspection identified that not all pipework had been inspected or replaced as part of the PICA remediation project and that the section of pipework on the East CO₂ plant that had failed was not included in this scope.
26. The section of failed pipework is included on the Written Scheme of Examination (WSE) to be inspected but the scope of inspections is left to the judgement of the PSSR competent person. The PSSR competent person was aware of the previous issues with CUI but mistakenly believed that this section of pipework had been refurbished in 2009 and hence was not a priority for his inspections. We reviewed the previous records of maintenance undertaken on the CO₂ system under the WSE. Unfortunately the quality of the maintenance records undertaken under PSSR were extremely poor as they did not identify ;
- The specific location within the sub-section of plant that was inspected
 - How the sample locations were selected (procedure indicates that areas are determined by the competent person where water ingress is suspected or leakage is noted).
 - The scope and extent of the inspections (ie was lagging removed, if non-destructive ultrasonic thickness checks were made and if so, what the results were).
27. There has also been recent incidents associated with shortfalls against PSSR requirements at the licensee's other sites, which have been raised with the licensee as discussed in section 2.1.2 of this PAR.
28. Given these findings I recommend that ONR issues an immediate Improvement Notice under LC28 to ensure that adequate maintenance is undertaken on the East CO₂ plant before it is brought back into service.

3.3.2 CONSIDERATION OF FURTHER ENFORCEMENT ACTION

29. Given the previous incidents and ONR advice coupled with the potential significant consequences of this event, I recommend that ONR undertakes a formal investigation to determine if there are grounds for further enforcement action.

4 CONCLUSIONS

30. This report presents the findings of the preliminary investigation into an incident on Heysham 1 site which resulted in the failure of a high pressure CO₂ pipe on the East CO₂ plant.
31. From the documents provided by the licensee and the information provided through discussion with licensee staff and nominated competent persons, I consider there to be a significant shortfall against the requirements of LC28, and I judge the licensee's arrangements for examination, inspection, maintenance and testing, of the CO₂ pipe on the East CO₂ plant to be unacceptable. I consider this shortfall is likely to have contributed to the incident occurring, resulting in the loss of approximately 40 tonnes of clean CO₂ from a plant that has an associated nuclear safety function.
32. My judgement is supported by previous incidents both at Heysham 1 site and across the fleet that demonstrate the licensee was aware of the potential for plant failures of this nature. This is further enhanced by the information provided that indicates the licensee was aware of such issues but as of yet have failed to do so. Recommendations made by the licensee's own internal inspection reports issued in December 2010 identified the requirement to include the CO₂ storage plant pipework on the maintenance schedule, which again, I could find no evidence of implementation or reasons for dismissal.
33. Although no one was injured as a result of this incident, I judge that the potential for injury to have occurred was only minimised as a result of the incident occurring during non-social hours when the workforce was at a minimum. I also consider the plant to be important for nuclear safety and this incident has reduced the level of defence in depth available to the licensee should a response be required for any future event.

5 RECOMMENDATIONS

34. This project assessment report recommends that ONR should issue an Improvement Notice for contraventions under HSWA, s2(1) and s3(1), the Management of Health and Safety Regulations (1999) Regulation 5(1) and the most appropriate Licence Condition - LC28.
35. ONR should conduct a full investigation to determine the cause of the failure and identify if further regulatory action is required to secure improvement.

6 REFERENCES

1. *The use of the Enforcement Management Model in ONR– Operational Version 3.2*
<http://www.onr.org.uk/operational/assessment/index.htm>
2. *Safety Assessment Principles for Nuclear Facilities*. 2014 Edition Revision 0.
November 2014. <http://www.onr.org.uk/saps/saps2014.pdf>.
3. *EDF Energy Nuclear Generation Limited – Heysham 1 – CO₂ Storage and Distribution System* – ONR-HYA-IR-14-007 - June 2015 (TRIM 2014/249519)
4. *EDF NGL - Compliance with the Pressure System Safety Regulations 2000* – Letter Reference GEN 71326R - December 2013 (TRIM 2013/461399)
5. *EDF NGL - Heysham 1 Power Station Preliminary Investigation of a Pipe Failure on the East CO₂ Storage Plant* – ONR-HYA-IR-14-236 - March 2015 (TRIM 2015/112421)



Figure 1: Photograph of the failed pipe taken after isolation of the CO₂ storage plant.

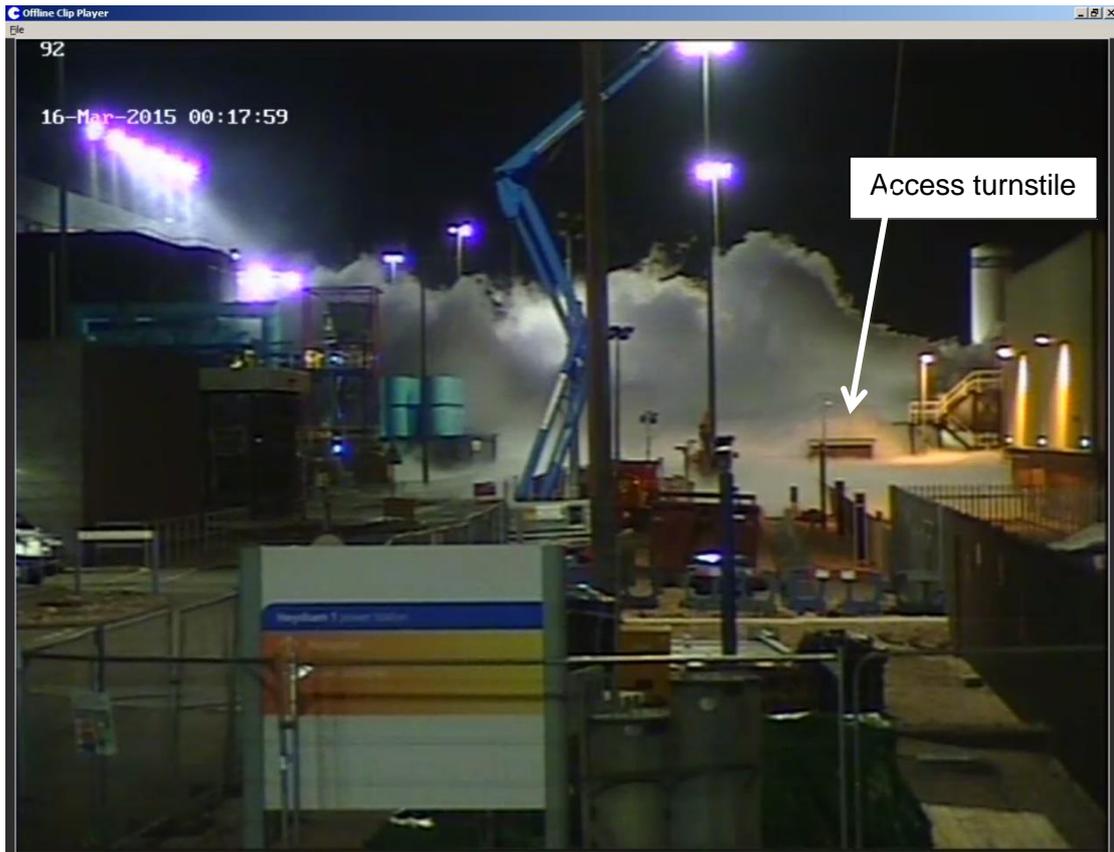


Figure 2: Still screen grab taken from the security camera video footage showing the extent of the CO₂ release and the affected area.