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**Corrosion Management Arrangements at Dungeness B Power Station**  
**Direction to Dungeness B Power Station to Carry Out a Review and Reassessment of**  
**Safety Addressing the Corrosion of Concealed Systems**

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## EXECUTIVE SUMMARY

### Title

Direction to Dungeness B Power Station to Carry Out a Review and Reassessment of Safety Addressing the Corrosion of Concealed Systems

### Introduction

Since April 2016, ONR has completed numerous corrosion focussed inspections at Dungeness B Power Station (DNB). These have been conducted as part of its ongoing intervention for the management of corrosion across EDF Nuclear Generation Limited's (NGL) operating fleet of nuclear power stations.

Following the most recent of these inspections a number of significant shortfalls remained against DNB's corrosion management arrangements. Application of ONR's Enforcement Management Model (EMM) concluded that a Direction under Licence Condition (LC) 15 (4) would be an effective and proportionate response. The relevant LC states that; "The licensee shall, if so directed by ONR, carry out a review and reassessment of safety and submit a report of such review and reassessment to ONR at such intervals, within such a period and for such of the matters or operations as may be specified in the direction."

This report sets out the justification for issuing NGL with a Direction under LC15 (4), namely to give ONR confidence that DNB are suitably managing the risk posed to nuclear safety by corrosion.

### Background

Nuclear power stations contain many miles of steel pipework which may be subject to degradation via external corrosion. A mechanism of particular interest is corrosion under insulation (CUI). The external insulation and cladding conceals the pipe, making meaningful inspection more challenging. Some types of insulation exacerbate degradation rates by retaining moisture where the cladding on the insulation has not been sealed.

Under LC28 (1), NGL must ensure that it has adequate arrangements embedded for the regular and systematic examination, inspection, maintenance and testing of concealed pipework which may affect safety at DNB.

NGL's fleet has suffered from a number of corrosion related plant failures or near misses, one of the most significant of which occurred on the East CO2 plant at Heysham 1 power station (HYA) in March 2015. This event resulted in an Improvement Notice being served on HYA, requiring improvements to be made in the maintenance of the CO2 plant and for the licensee to consider the implications across the fleet.

In response to the potential threat to concealed Structures Systems and Components by CUI and associated plant failures, ONR initiated a specific intervention to assess the adequacy of NGL's arrangements to manage their integrity. ONR initially targeted this intervention specifically on concealed pipework as the failure and intelligence from previous failures/near misses on NGL sites suggested that concealed pipework was a particularly challenging area. The intervention then expanded to cover all concealed, buried and trenched systems.

### Assessment and inspection work carried out by ONR

ONR's approach during this intervention was to carry out an initial benchmarking phase to review the scope of NGL's fleetwide corrosion strategy. This sampled factors such as training, inspection, guidance, adherence to company standards, recording of judgements, and remediation of defects, amongst others. Phase 1 of the intervention took place throughout 2016 and resulted in a number of follow up inspections being required.

After this initial phase, NGL were given time to consider ONR's findings and implement a number of compliance improvements. In phase 2, ONR then conducted a further series of station inspections to assess how these improvements had been embedded into station arrangements for the provision of suitable Examination, Maintenance, Inspection and Testing of SSCs susceptible to corrosion.

Specifically for DNB, ONR has now completed 5 corrosion focussed inspections, beginning in April 2016, with the most recent in July 2018. This compares with an average of 2 corrosion focussed inspections per station for the remainder of NGL's fleet. Since January 2017 a station specific level 2 Regulatory Issue has been in place, which has a number of associated actions for DNB to resolve shortfalls identified during past inspections.

ONR has discussed DNB's corrosion management process at all levels within the station, as well as with senior members of NGL's Central Technical Organisation (CTO) at Barnwood. We have explained the nature of the shortfalls identified and provided advice on the potential means by which DNB could address our concerns.

The most recent corrosion focussed inspection at DNB took place in July 2018. The primary aim of the inspection was to assess the adequacy of arrangements related to their corrosion management programme; this was particularly focussed upon previously identified shortfalls. Additionally, follow up discussions took place relating to maintenance schedule activities for the CO<sub>2</sub> plant and discovery of corrosion on the Buffer Store Back up Cooling Water system.

### **Matters arising from ONR's work**

Following the last inspection in July 2018, an inspection rating of RED was considered appropriate. In light of this rating, the Enforcement Management Model (EMM) was applied to determine the most appropriate enforcement action. In summary, when considering the nature of the identified shortfalls, application of the EMM has identified that use of LC powers would be a proportionate response.

### **Conclusions**

ONR considers that NGL have made insufficient progress in implementing arrangements required under LC28 (1) for regular and systematic examination, inspection, maintenance and testing of concealed pipework which may affect safety at Dungeness B Power Station.

The proposed formal enforcement action will ensure that NGL review the implications of noncompliance to nuclear safety and submit to ONR a prioritised plan to deliver sustained compliance.

For the examples of degradation observed during the most recent inspection, DNB have provided evidence to give sufficient confidence that the integrity of the affected components is not challenged in the short term, there was no immediate risk to employees or the public, or a requirement to seek immediate shutdown of the affected plant. However I consider it is necessary for DNB to complete a more comprehensive review of safety for their concealed systems by 22<sup>nd</sup> October 2018. This review will provide DNB with the required level of detail to establish the extent of condition for their concealed systems and to clearly identify any necessary remedial actions.

The timescale associated with delivery of NGL's review of safety to ONR is planned to coincide with the anticipated restart of Reactor 22 at DNB, following its statutory outage. ONR have informed NGL that consent for restart will, in part, be dependent upon a satisfactory outcome from the review.

### **Recommendation**

I recommend that ONR issues NGL with a Direction under LC15 (4) as follows: This Direction should require DNB to carry out a review and reassessment for the safety of its concealed systems and submit a report to ONR for review by 22<sup>nd</sup> October 2018.

“NGL carry out a review and reassessment of safety, addressing the corrosion of concealed systems that fulfil a safety function and submit a report of the review and reassessment to ONR. ONR specifies that this review and reassessment includes:

- 1) All concealed Systems, Structures and Components at risk from corrosion and that fulfil a safety function.
- 2) A clear demonstration that the risk arising from the operation of Dungeness B continues to be as low as reasonably practicable (ALARP). This should take full account of any identified corrosion, or any uncertainty from lack of recent inspection results. Judgements should be based upon sound evidence.”

I also recommend that the letter supporting the Direction makes it clear that in addressing the Direction NGL will be required to:

- Clearly demonstrate to ONR that it understands the extent of condition for its inaccessible, concealed or trenched systems.
- Provide a detailed plan of how it intends to remediate all corrosion related defects, clearly prioritised upon the potential risk to nuclear safety and that the plan should define milestones for key deliverables, as well as any discovery milestones, such as those associated with uncovering trenches.

## LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
CUI	Corrosion under Insulation
DNB	Dungeness B Power Station
EIMT	Examination, Inspection, Maintenance and Testing
EMM	Enforcement Management Model
HOW2	(Office for Nuclear Regulation) Business Management System
LC	License Condition
NGL	EDF Nuclear Generation Ltd
ONR	Office for Nuclear Regulation
SAP	Safety Assessment Principle(s)
SSC	Structure, System and Component



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## 1 INTRODUCTION

1. Since April 2016, ONR has completed numerous corrosion focussed inspections at Dungeness B Power Station (DNB) (Refs. 1, 2, 4, 5 & 6). These have been conducted as part of its ongoing intervention for the management of corrosion across EDF Energy Nuclear Generation Ltd's (NGL) operating fleet of nuclear power stations.
2. Following the most recent of these inspections (Ref. 6) a number of significant shortfalls remained against DNB's corrosion management arrangements. Application of ONR's Enforcement Management Model (EMM) (Ref. 7) concluded that a Direction under Licence Condition (LC) LC15 (4) would be an effective and proportionate response.
3. This PAR will set out the justification to issue NGL with a Direction under LC15 (4), namely to give ONR confidence that DNB are suitably managing the risk posed to nuclear safety by corrosion. The relevant LC states that; "*The licensee shall, if so **directed** by ONR, carry out a review and reassessment of safety and submit a report of such review and reassessment to ONR at such intervals, within such a period and for such of the matters or operations as may be **specified** in the direction.*"

## 2 BACKGROUND

4. Nuclear power stations contain many miles of steel pipework which may be subject to degradation via external corrosion. A mechanism of particular interest is corrosion under insulation (CUI). The external insulation and cladding conceals the pipe, making meaningful inspection more challenging. Some types of insulation exacerbate degradation rates by retaining moisture where the cladding on the insulation has not been sealed.
5. Under LC28 (1), NGL must make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing (EIMT) of concealed pipework which may affect safety at DNB. These arrangements should ensure that the degradation due to corrosion is detected and (if necessary) ensure timely remedial work is undertaken to maintain pipework integrity.
6. NGL's fleet has suffered from a number of corrosion related plant failures or near misses, one of the most significant of which occurred on the East CO2 plant at Heysham 1 power station (HYA) in March 2015. NGL's initial investigation identified wall thinning due to CUI resulting from moisture ingress where cladding had been adjusted to fit around a structural beam. A station led investigation acknowledged the root cause to be "*The failure to implement an effective ageing and corrosion management process*". This event resulted in an Improvement Notice being served on HYA, requiring improvements to be made in the maintenance of the CO2 plant, in addition the licensee was required to consider the implications across the fleet. In response, NGL introduced technical standards for corrosion and ageing management (CTS031), fleet and station corrosion co-ordinators, initiated fleet and station corrosion user group meetings and provided oversight via a fleet steering group and their internal regulator.
7. In response to the potential threat to concealed SSCs by CUI and associated plant failures, ONR initiated a specific intervention to assess the adequacy of NGL's arrangements to manage their integrity. ONR initially targeted this intervention specifically on concealed pipework as the failure and intelligence from previous failures/near misses on NGL sites suggested that concealed pipework was a particularly challenging area. The intervention then expanded to cover all concealed, buried and trenched systems.

### 3 ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR

8. ONR's approach during this intervention was to carry out an initial benchmarking phase to review the scope of NGL's fleetwide corrosion strategy. To establish how NGL's strategy was implemented at station level, this review was followed by a series of benchmarking inspections carried out by ONR Structural Integrity Specialist Inspectors at a number of stations. This included sampling factors such as training, inspection, guidance, adherence to company standards, recording of judgements, and remediation of defects, amongst others. At the end of phase 1, a meeting was held with NGL to provide feedback on findings, any areas of good practice, areas for improvement and in some cases shortfalls against LC28, enforcement communications were used as appropriate to inform NGL. Phase 1 of the intervention took place throughout 2016 and resulted in a number of follow up inspections being required.
9. In response to compliance shortfalls NGL developed an improvement programme to achieve compliance. During phase 2, ONR conducted a series of inspections to evaluate NGL's progress in embedding improvements.
10. Specifically for DNB, ONR has now completed 5 corrosion focussed inspections (Refs. 1, 2, 4, 5 & 6), beginning in April 2016, with the most recent in July 2018. In January 2017, a level 2 Regulatory Issue (number 4385), was raised in response to limited progress and shortfalls in the implementation of NGL's corrosion management arrangements at DNB.
11. ONR has discussed DNB's corrosion management process at all levels within the station, as well as with senior members of NGL's Central Technical Organisation (CTO) at Barnwood. We have explained the nature of the shortfalls identified and provided advice on the potential means by which DNB could address our concerns.
12. ONR Structural Integrity Inspectors', attended the most recent corrosion focussed inspection at DNB in July 2018 (Ref. 6). The primary aim of the inspection was to perform a follow up inspection at DNB to assess the adequacy of arrangements related to their corrosion management programme. This was particularly focussed upon previously identified LC28 (1) shortfalls with respect to the management and prioritisation of corrosion related plant inspections and subsequent defect remediation activities. Additionally, the opportunity was taken to conduct follow up discussions relating to maintenance schedule activities for the CO2 plant and discovery of corrosion on the Buffer Store Back up Cooling Water system, along with its subsequent remediation. Further details and conclusions are contained in Ref. 6, and fall under the following themes:

#### **Defect Tracking Spreadsheet**

13. From the information presented in the defect tracker spreadsheet and during discussion throughout the inspection, ONR did not consider that DNB demonstrated robust and embedded arrangements for prioritising defect remediation based upon risk and evidence from any previous inspections. Specifically, the defect tracker spreadsheet used at DNB contains columns whereby engineering are expected to provide evidence to support their judgements relating to the sentencing of any identified corrosion. Several entries sampled during the inspection did not provide clear judgements or evidence to provide a justifiable decision for continued service pending remediation. A large number of high priority defects had no apparent planned dates for remediation.
14. In section 5 of its technical inspection guide for LC28 (Ref. 10), ONR expects its licensees to maintain adequate records demonstrating that they have completed the necessary EIMT. ONR considers that, DNB have not been able to demonstrate it has

implemented adequate arrangements to record the basis for sentencing decisions related to identified corrosion degradation. ONR judge this is a shortfall against LC28 (1).

### **Prioritisation of Inspection and Remediation**

15. During this inspection ONR Inspectors' witnessed or discussed examples of plant degradation relating to the Buffer Store Back up Cooling Water (BS BUCW) pipework and supports, Back up Feedwater Tanks (BUFW) and Essential Cooling Water Reactor (ECWR) pipework.
16. Sections of the ECWR pipework are planned for renewal during the 2018 R22 outage. However, the pipework has been in a degraded state for an extended period of time, with no evidence of suitable EIMT provided, ONR judge that this is a shortfall against LC28 (1). In relation to the BS BUCW trenched pipework, ONR consider that DNB responded appropriately once it had discovered significant corrosions in January 2018. However, there had been evidence of past water ingress and corrosion within the trenched pipework.
17. For the examples of degradation observed during the most recent inspection, DNB have provided evidence to give sufficient confidence that the integrity of the effected components is not challenged in the short term and there was no requirement to seek immediate shutdown of the effected plant. However, ONR consider that the examples provide evidence to challenge the judgement process behind DNB's prioritisation of trench inspection and remediation work. ONR judge that it is necessary for DNB to complete more comprehensive review of safety for their concealed systems by 22<sup>nd</sup> October 2018.

### **Trenches**

18. Out of the 138 trenches at DNB, 42 have been identified as high priority for inspection, based upon the significance of systems contained, materials of construction, presence of insulation, potential for trench flooding and known issues from past inspections.
19. DNB has informed ONR that it is anticipated to take until the end of 2020 for the 42 high priority trenches to complete its inspection. ONR do not consider that DNB has provided suitable evidence to demonstrate a robust process for prioritising the inspection of its 42 high priority trenches. Ref. 10 section 5 states that all EIMT should be conducted at suitable timescales and identified in the licensee's maintenance schedule. ONR consider that the lack of this information for the trenches at DNB is a shortfall against the requirements of LC28 (1).

### **CO2 System**

20. ONR is content that DNB was able to demonstrate that maintenance routines exist for pipework inspection. However ONR consider that improvements could be made in relation to the unexplained differences in routines for seismically qualified and non-qualified pipework. It was also challenging for DNB to identify which areas of pipework had been inspected.
21. DNB informed ONR that it has identified a shortfall in its maintenance routines for the CO2 system. No additional routines exist that require inspection of the tanks to aid compliance with LC28; they currently appear to address PSSR requirements alone. ONR consider the lack of robust and embedded maintenance routines for this system to be a shortfall against the requirements of LC28 (1).

#### 4 MATTERS ARISING FROM ONR'S WORK

22. Following the last inspection in July 2018 (Ref. 6), an inspection rating of RED was considered appropriate. In light of this rating, the EMM was applied to determine the most appropriate enforcement action. Details of this decision have been captured in Ref. 7. In summary, when considering the nature of the identified shortfalls, application of the EMM identified that NGL is in contravention of:

The Health and Safety at Work Act (HSWA74), Section 2: General duties of employers to their employees, namely:

*(1) It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.*

and Section 3: General duties of employers and self-employed to persons other than their employees, namely:

*3(1) It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.*

and NGL Site Licence number 61, Licence Condition 28: Examination, inspection, maintenance and testing, namely:

*(1) The licensee shall make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing of all plant which may affect safety.*

23. ONR cannot currently be confident that these safety-significant systems will not fail when demanded, providing both a risk of serious personal injury to NGL employees and contractors and a potential nuclear safety risk through non-delivery of their safety function. NGL have committed to delay restart of both reactors at DNB from their current outages until they can demonstrate to ONR that they have reduced the risk of corrosion related failure of their significant systems to tolerable and ALARP. If content, ONR will provide consent to restart for R22 at the completion of its statutory outage, whilst the formal decision to restart R21 from its refuelling outage rests with NGL.
24. For the reasons set out in Ref. 7 a Direction under LC15 (4) "The licensee shall, if so directed by ONR, carry out a review and reassessment of safety and submit a report of such review and reassessment to ONR at such intervals, within such a period and for such of the matters or operations as may be specified in the direction" is considered to be the most effective and proportionate enforcement action.
25. The primary aim of the proposed Direction is for NGL to demonstrate that the risk arising from the operation of DNB continues to be as low as reasonably practicable (ALARP). Consequently ONR propose that a Direction be made as follows:
- "NGL carry out a review and reassessment of safety, addressing the corrosion of concealed systems that fulfil a safety function and submit a report of the review and reassessment to ONR. ONR specifies that this review and reassessment includes:
- All concealed Systems, Structures and Components at risk from corrosion that fulfil a safety function.

- A clear demonstration that the risk arising from the failure of concealed systems that fulfil a safety function at DNB continues to be as low as reasonably practicable (ALARP). This should take full account of any identified corrosion, or any uncertainty from lack of recent inspection results. Judgements should be based upon sound evidence.”
26. It is the view of ONR that this review and reassessment needs to be completed and reported as a matter of urgency and on a timescale commensurate with the planned return to service of DNB Reactor 22 in early November 2018 following its statutory outage.
27. In order to progress as quickly as possible the intent of the proposed Direction ONR held a meeting with NGL on 17<sup>th</sup> August to discuss the way forward (Ref.9). At this meeting, ONR outlined concerns and indicated the intention to issue a Direction under LC15 (4) and also made it clear that in addressing the Direction NGL will be required to:
- Clearly demonstrate to ONR that it understands the extent of condition for its inaccessible, concealed or trenched systems.
  - Provide a detailed plan of how it intends to remediate all corrosion related defects, clearly prioritised upon the potential risk to nuclear safety and that the plan should define milestones for key deliverables, as well as any discovery milestones, such as those associated with uncovering trenches.
28. ONR also suggested that DNB produce a strategy document to outline how they will meet the Direction. NGL has agreed to produce such a document. NGL also agreed to complete the requirements in the outstanding Regulatory Issues (4385, 4976 & 5906).

## 5 CONCLUSIONS

29. ONR considers that NGL have made insufficient progress in implementing arrangements required under LC28 (1) for regular and systematic examination, inspection, maintenance and testing of concealed pipework which may affect safety at DNB.
30. The proposed formal enforcement action will ensure that NGL review the implications of noncompliance to nuclear safety and submit to ONR a prioritised plan to deliver sustained compliance.
31. For the examples of degradation observed during my most recent inspection, DNB have provided evidence to give sufficient confidence that the integrity of the effected components is not challenged in the short term and there was no requirement to seek immediate shutdown of the effected plant. However ONR consider it is necessary for DNB to complete more comprehensive review of safety for their concealed systems by 22<sup>nd</sup> October 2018. This review will provide DNB with the required level of detail to establish the extent of condition for their concealed systems and to clearly identify any necessary remedial actions.
32. The timescale associated with delivery of NGL's review of safety to ONR is planned to coincide with the anticipated restart of Reactor 22 at DNB, following its statutory outage. ONR have informed NGL that consent for restart will, in part, be dependent upon a satisfactory outcome from the review.

## 6 RECOMMENDATIONS

33. I recommend that ONR issues NGL with a Direction under LC15 (4) as follows:
34. "NGL carry out a review and reassessment of safety, addressing the corrosion of concealed systems that fulfil a safety function and submit a report of the review and reassessment to ONR by the 22<sup>nd</sup> October 2018. ONR specifies that this review and reassessment includes:
  - All concealed Systems, Structures and Components at risk from corrosion that fulfil a safety function.
  - A clear demonstration that the risk arising from the failure of concealed systems that fulfil a safety function at DNB continues to be as low as reasonably practicable (ALARP). This should take full account of any identified corrosion, or any uncertainty from lack of recent inspection results. Judgements should be based upon sound evidence."
35. I also recommend that the letter supporting the Direction makes it clear that in addressing the Direction NGL will be required to:
  - Clearly demonstrate to ONR that it understands the extent of condition for its inaccessible, concealed or trenched systems.
  - Provide a detailed plan of how it intends to remediate all corrosion related defects, clearly prioritised upon the potential risk to nuclear safety and that the plan should define milestones for key deliverables, as well as any discovery milestones, such as those associated with uncovering trenches.



## 7 REFERENCES

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