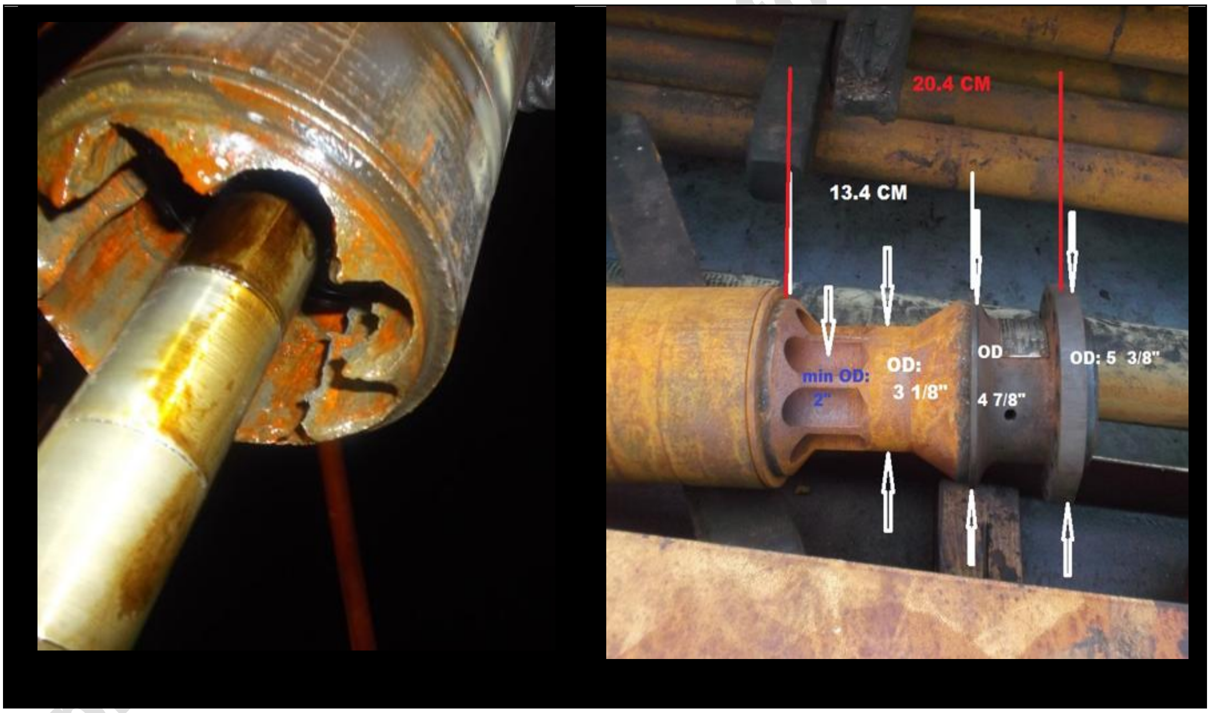
EXPERT WITNESS REPORT (ANONYMIZED):

INVESTIGATION OF PREMATURE ESP PUMP FAILURES IN AN OIL FIELD



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TO: THE COURT

EXPERT WITNESS REPORT – [redacted] COMPLIANT

IN THE MATTER OF: Investigation of Premature ESP Pump Failures in an Offshore Oil Field

INSTRUCTED BY: [redacted]

EXPERT: Dr. Mohammad Hosseini, CEng, CSci, FIMMM, FICorr

DATE OF REPORT: [redacted]

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1. SUMMARY OF CONCLUSIONS

1.1 The premature failures of Electrical Submersible Pumps (ESPs) in three offshore oil wells occurred after approximately two years of service—significantly below expected run life.

1.2 The root cause of failure was internal general CO_2 corrosion (sweet corrosion) of carbon steel components in the Rotary Gas Separator (RGS) intake section, resulting in wall thinning and through-wall rupture ("cut").

1.3 Contributing factors included:

- ***Use of non-sour-service materials (AISI 1040 carbon steel) not compliant with NACE MR0175/ISO 15156;***
- ***Absence of corrosion inhibitor injection;***
- ***High CO_2 partial pressure (~142 psi), mildly sour conditions (H_2S ~583 ppm), and high-chloride formation water (~70,000–90,000 ppm Cl^-).***

1.4 Alternative failure mechanisms were evaluated and excluded:

- ***Cavitation: Ruled out at the actual failure location (RGS inlet channels); operational changes (increased gas and water) reduce, not increase, cavitation risk.***
- ***Erosion/sand wear: No sand production reported; no erosion patterns observed.***
- ***H_2S-induced cracking: No cracking observed; material hardness <250 HV; environment not sufficiently sour.***
- ***Galvanic or microbial corrosion: No credible evidence; temperature too high for MIC.***

1.5 The third-party laboratory report attributing failure to cavitation was based on tests of the wrong component (flow-divider instead of intake) and contained analytical errors; its conclusions are not supported by the evidence.

1.6 Recommended remedial actions: use of corrosion-resistant alloys (CRA) in intake sections, implementation of corrosion inhibitor programs, and periodic fluid chemistry monitoring.

1.7 This opinion is expressed to a high degree of engineering certainty based on field data, metallurgical principles, and failure morphology.

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2. EXPERT'S QUALIFICATIONS AND RELEVANT EXPERIENCE

2.1 I am Dr. Mohammad Hosseini, Chartered Engineer (CEng), Chartered Scientist (CSci), and Fellow of both the Institute of Materials, Minerals and Mining (FIMMM) and the Institute of Corrosion (FICorr).

2.2 I hold a PhD in Materials and Corrosion Engineering and have over 21years of experience in failure analysis, corrosion engineering, and materials selection for oil and gas systems, including subsea and downhole equipment.

2.3 I have authored or co-authored more than 30 technical publications on metallurgy and corrosion engineering and served in the capacity of forensic engineer and expert witness in 12 different cases involving material failures in oil and gas, renewables, and infrastructure sectors.

2.4 My full curriculum vitae is attached as Appendix 1.

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3. SUBSTANCE OF INSTRUCTIONS

3.1 I was instructed on 10 November 2020 by [redacted] to determine the root cause of premature ESP failures in three wells (anonymized as N-6, D-5, and NTH-1) and to evaluate the validity of a third-party failure analysis report.

3.2 I was asked to:

- *Identify the dominant failure mechanism(s);*
- *Assess whether material selection, operating conditions, or chemical environment contributed;*
- *Review and critique the external laboratory report (Report No. 2983);*
- *Recommend corrective actions to prevent recurrence.*

3.3 A copy of my formal instructions is attached as Appendix 2.

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4. MATERIAL FACTS AND ASSUMPTIONS

4.1 Facts within my knowledge (based on physical evidence, data review, and calculations):

- ***Failed ESP components were made primarily of AISI 1040 carbon steel;***
- ***No corrosion inhibitors were used in the subject wells;***
- ***Visual and photographic evidence shows severe wall thinning and corrosion product in the RGS intake;***
- ***The failure location was confirmed to be in the inlet channel section, not the flow-divider;***
- ***Operator data confirms high CO_2, low H_2S, and high water cut.***

4.2 Facts provided by others (assumed accurate for the purpose of this report):

- ***Production data (GOR, pressure, temperature) from operator;***
- ***Gas composition (3.55 mol% CO_2, 583 ppm H_2S);***
- ***Formation water chemistry estimates (70,000–90,000 ppm Cl^-, 250–600 ppm HCO_3^-).***

4.3 Key assumptions (where direct data was unavailable):

- ***Corrosion rate estimated using industry-standard model (Predict 6.0) under conservative assumptions;***
- ***No oxygen ingress or sand production (as confirmed by operator).***

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5. OPINIONS AND REASONS

5.1 My primary opinion is that CO_2-driven uniform corrosion caused the failure. This is supported by:

- ***Material vulnerability (carbon steel in CO_2-rich brine);***
- ***Absence of inhibition;***
- ***Observed morphology (general thinning, iron carbonate scale);***
- ***Calculated corrosion rates (0.5–1.5 mm/year) consistent with 2-year failure timeline.***

5.2 Cavitation was not the cause. While minor pitting consistent with cavitation was found in the flow-divider (a non-failed component), the actual failure occurred in the multiphase inlet channel where:

- ***Pressure recovery is absent (no bubble collapse mechanism);***
- ***Increased gas and water reduce fluid volatility, lowering cavitation risk.***

5.3 Other mechanisms (erosion, cracking, MIC) were excluded based on absence of characteristic damage features and environmental conditions.

5.4 The external report is flawed: it misidentified the failure location, misinterpreted EDS data, and drew unsupported conclusions about cavitation and galvanic corrosion.

5.5 On contested matters (e.g., corrosion vs. cavitation), I have summarised the range of expert opinion in the field and explained why my view—based on thermodynamics, fluid mechanics, and field evidence—is correct. (See Sections 5 and 6 of this report.)

6. LIST OF DOCUMENTS AND MATERIAL RELIED UPON

The following materials were reviewed and relied upon:

- ***Operator production and fluid data (Tables 3-1);***
- ***ESP material specifications (Table 3-2);***
- ***Photographs of failed components (Figures 4-1, 6-1 to 6-4);***
- ***Third-party laboratory report (No. 2983);***
- ***NACE MR0175/ISO 15156 standard;***
- ***Corrosion engineering references (e.g., Uhlig's Corrosion Handbook).***

A full list is provided in Appendix 3.

7. QUALIFICATIONS TO OPINIONS

7.1 My conclusions are qualified only by the limited availability of well-specific fluid chemistry. Direct water analysis from the subject wells was not provided, so estimates were used. However, even conservative assumptions support the CO_2 corrosion mechanism.

7.2 Should new evidence emerge (e.g., proof of inhibitor use, sand production, or material certification errors), I reserve the right to revise this opinion.

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8. STATEMENT OF COMPLIANCE

I confirm that:

- ***I understand my duty to the Court under [redacted], [redacted] to provide independent, objective, and unbiased opinion;***
- ***My report complies with [redacted] Guidance for the Instruction of Experts;***
- ***I have not been influenced by any party in forming my opinions.***

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9. STATEMENT OF TRUTH

I believe that the facts stated in this report are true and that the opinions expressed are my genuine professional views based on my expertise and the evidence available.

Signed:
Dr. S. Mohammad Hosseini, *CEng, CSci, FIMMM, FICorr*

Date: [redacted]

APPENDICES

- ***Appendix 1: Expert's CV***
- ***Appendix 2: Instructions from Instructing Party***
- ***Appendix 3: Documents and Evidence Reviewed***
- ***Appendix 4: Figures and Photographs***
- ***Appendix 5: Glossary of Technical Terms***
- ***Appendix 6: Reference Publications***