DANSK VANDBYGNINGSTEKNISK SELSKAB
DANISH SOCIETY OF HYDRAULIC ENGINEERING
v/ H. F. Burcharth, AUC, Sohngårdsholmsvej 57, 9000 Aalborg. Tlf. 08 - 142333
Denmark

1985-11-26
HG/at

Re.: Seminar on Danish Submarine Pipeline Guidelines

Enclosed we hereby forward:

./. - Minutes of seminar.
./. - Letter from Mærsk Oil & Gas
./. - Feedback from Bergsøe Anti Corrosion on cathodic protection.
./. - List of participant on seminar.

Yours sincerely,

Helge Gravesen

Encl.

Comments and Discussion During the Seminar 19. September.

1. <u>General Comments</u>

The guidelines should in phase 2 be developed also to cover the point of view of the owner of the pipelines and the authorities.
The formal status of the guidelines should be clarified and eventually changed to "Proposal for a Danish Marine Pipeline Design Practice" or "Danish Handbook of Marine Pipeline Design".

It should be mentioned that the guidelines correspond to design in accordance with ASME Guide plus Danish supplement plus ad hoc agreements with authorities obtained during the design and construction of Danish transmission and interfield pipelines. However, operational experiences of design has not been incorporated into the guidelines.

Desirable with list of codes and standards referred to.

Proposal for QA system to be mentioned more precisely.

The requirement should be established for independent check on all aspects of design (independent of both operator and designer).

The term 'submarine pipeline system'should be defined (e.g. is riser included, and to what point of deck piping). This point has caused difficulty in British sector.

Future editions shall consider Trenching, Backfilling and Self-burial.

2. Pipeline Process

The set pressure should be close to design pressure and systems should include indicators to counter for minimum regulating range e.g. safety valve/pressure increase protection. Slug catcher sizing to be included.

Maximum and minimum velocities (table 4.1) should distinguish between gas and liquid lines and between trunklines and interfield lines. The table covers trunklines with long design life. Fig. 4.10 could be misleading. It is proposed to review experienced conductivities from North Sea soils. Leak detection systems should also be auditive.

3. External Environment

Discussion on sedimentation/erosion is missing. Trenching in conditions like Storebaelt should be discussed. Discussions on utilization of different surveys to be included. Qualified interpretation of f.ex. sub-bottom and side scan surveys is vital. How to combine different surveys?
Interaction wave and current to be discussed.
Table 4.5 should be extended and discussed.
5.2.4 is incomplete (liquefaction, large stones)
5.2.7 different frequencies are required for soft and hard soil conditions.
Requirement to opening angle for echosounder to be given.
5.4.1 Typing error: Dynamic longitudinal friction may be taken as twice the coefficient of static friction.

4. Safety

Requirements for sub-sea valve should be related to consequences of leak/rupture. The requirement for the sub-sea

valve station in the Danish Transmission gas line was highly related to the sour (poisonous) contents of the gas. The discussion on specific valve system is too specific.
The risk level should distinguish between failure (small leak) and rupture. A valve is a complication to the system which by itself may induce extra risk for failure, e.g. due to anchor damage on valve. Discussion on risk safety should be consistent with requirements for riser protection in section 10.
It should be discussed if statistics of failures in Mexican Gulf may be applied for North Sea conditions.

Failure data may not be representative for modern design. Thus high P_F for oil land pipelines due to corrosion (Table 3.5) might be due to lack of cathodic protection.

The consequences of failures are too conservatively estimated, e.g. ineviatbility of ignition of escaping gas (3.2.1). Discussion of leak detection requirements should be evaluated (accuracy of leak detection system, different in gas and liquid lines, influence on operation).

5. Structural Design

Usual to use outer diameter in hoop stress analysis. 75% SMYS criteria for longitudinal stress should be included. Negative wall tolerance should distinguish between general plate under-thickness and local under-thickness. Defect criteria (2 mm) too general. Direct reference to D.O.N.G. project f. example page 81 should be left out. Flow Chart p. 73 shows that installation may require extra wall thickness. This should not be the case for lay stress criteria. Distinguish between deformation controlled load (strain criteria) and force controlled load (stress criteria). This distinction corresponds to proposal for DS320. Expansion is deformation controlled.

Different oppinion if rupture for hot restained pipeline occur for combined stress load equal to von Mises criteria or if rupture only occurs after yielding due to internal pressure, (so rupture hoop strees is equal to yield stress). This needs clarification.
Criteria for installation should relate to how accurately possible damages (denting, flattening, buckling, fatigue, overstraining) during installation could be identified.

Expansion offset is deformation controlled (strain criteria). Risers are both force controlled (upper part) and deformation controlled (lower part).

Upheaval should be itemised as a possible mode of failure for trenched/covered pipelines.

It was discussed if upheaval buckling could be allowed if no critical spans and if risk of damages due to fishing gear was small.

The discussion of buckling phenomena requires expansion to include upheaval buckling which is a consequence of lateral restraint (e.g. for trenched or covered pipelines).

Lateral snaking may be analysed by assuming a sinusoidal laying pattern, and considering lateral equilibrium.

Free span vortex induced vibration should be specified as a problem area to be checked.

Where possible complete riser/expansion loop/pipeline interaction should be modelled for analysis, including soil contact and sliding, and platform imposed deplacements.

Proposal to new DS 320 replaces class change by increased welding check.

P. 81 comment on 3-4 mm crack should be deleted as it is too general.

Improved detection of buckling should be specified (better buckling detector during laying, caliper surveys, utilization of cathodic potential survey to detect damages during trenching).

P 98 Formula for column force to be checked.

6. Stability

The case vertical stability of laid pipe (before trenching) should be included.
Dynamic analysis should include change in load coefficient during the wave cycle, which increases the forces during the second half cycle of the waves in combined waves/current load situation. The Ghazzaly method should be improved. The shear strength of soft soil is time dependent and should relate to the critical depth (not to shear strength above the pipeline). Experienced values should be mentioned for typical North Sea soft clay.

The wide range in estimates of required submerged weight could be due to increased short term resistance for low permeable soils (clay) and to combined scour/self-burial for friction type soils more than to details in hydrodynamic loads.

7. Material requirements and fabrication

Phase 2 should improve material criteria to higher level than criteria in DnV rules improved on carbon equivalent and on ductile fracture. The section should be more specific and not relate to a general statement on requirements to specification.
100% SMYS mill testing is a too general requirement.

Requirements to flexible pipes are missing, but to day there exist no guidelines for these pipes.
Hardness criteria could be increased (to 280 HV5) for sweet gas service.
Elongation criterion for cost and forged steels should be reconsidered.

8. Corrosion protection

The requirement to anode fabrication (cracks, contents of Al in Zn anodes and of Fe in Al anodes) should be revaluated because rigid criteria may give rise to extra costs when the criteria do not correspond to standard production of Zn and Al.
Requirements to coatings should, if possible be given as performance criteria. It would be desirable to distinguish between corrosion coating alone and corrosion coating in combination with weight coating.

MÆRSK

MÆRSK OLIE OG GAS A/S

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RAMBØLL & HANNEMANN A/S
Teknikerbyen 38
2830 Virum

Attn.: Helge Gravesen

21 November 1985
SM-06-019
049/RT/cst

Dear Sir

Subject: Comments to "Danish Submarine Pipeline Guidelines" First Draft July 1985.

The following comments relate to the above document which was initially issued to Mærsk Olie og Gas A/S August 1985 for review and further discussed during a seminar held at Danmarks Tekniske Højskole September 1985.

1. The document is of a general nature covering the management, design, fabrication, and installation aspects of Danish Submarine Pipelines and as such provides a useful overview of existing codes and standards and recent pipeline design work carried out by D.H.I. and R.& H. Recognising that the document is not intended to be a code or standard to be adopted for the complete spectrum of design, manufacture and construction we recommend that the title be ammended to "Engineering Handbook for Danish Submarine Pipelines".

2. Section 4

   It is relevant to have a pipeline process chapter included in the guideline but the content should be brought up to current industry standard practice.

3. Section 6.7.5, paras 1 and 2

   You state that a combination of lowering and bridging (asphalt mattresses) is unacceptable at pipeline crossing locations. We have previously utilized this technique and have additionally dumped rock over the upper pipeline and consider the results to be acceptable.

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In light of recent scour problems encountered with prefabricated tubular frames in the Danish sector we consider it inappropriate to recommend this solution for pipeline crossings.

4. <u>Section 10.2, paras 3 and 4</u>

Clarification of Danish Authorities lowering requirements should be included.

5. <u>Section 10.3.2, last para</u>

If welded wire mesh is used as supplementary reinforcement care should be taken to ensure that all reinforcement (rebar and mesh) is compatable to avoid possible galvanic corrosion.

Yours faithfully
for MÆRSK OLIE OG GAS A/S

Bent Lyngberg

Bergsøe Anti Corrosion

BAC

Rambøll & Hannemann,
Rådgivende Ingeniører A/S,
Teknikerbyen 3,
2830 Virum.

1985-10-08
HB/lk 57

Att.: Ingeniør Helge Gravesen.

Re: Industry Feedback on Danish Submarine Pipeline Guidelines,
First draft, July 1985.

Dear Sir.

We, Bergsøe Anti Corrosion, take the opportunity to comment and forward suggestions on your DSPG as requisted in point 1.8 of the DSPG.

We have suggestions on two subjects in part 9.4 "Cathodic protection", and we have taken the liberty of reediting the points in question, namely:

1. Point 9.4.5. "Environmental conditions" should be a little extended as per proposed test inclosed.

2. Point 9.4.8. "Anode Fabrication and Installation" should be extended to allow a more diversified selection of anode alloys together with recommendations on reinforcement design and a recommended standard of acceptance as per proposed text enclose

We trust that our proposals are of value to you and are at your service on any question you may have regarding cathocic protection.

Yours sincerely
BERGSØE ANTI CORROSION

Henrik Blomdahl
Manager offshore, div.

Enclosures: Six (6) text pages.

cc The Editor Submarine Pipeline Guidelines,
Danish Hydraulic Institute,
Agern Alle 5, 2970 Hørsholm.

PROCEDURES ADOPTED IN DANISH/NORDIC PROJECTS	GUIDELINE RECOMMENDATION	DISCUSSION FURTHER STUDIES ETC.
	9.4.5. Environmental Conditions The following parameters should be taken into account in the design: - Operating temperature - Ambient temperature - Chemical composition and oxygen content of environment - Resistivity of environment - Biological activity of environment - Current velocity of seawater. The specific resistance of North Sea seawater may be taken as 33 Ohm cm. For open Danish internal waters the specific resistance may be taken as 50 Ohm cm and 90-100 Ohm cm may be taken for seawater in Danish part of the Baltic Sea. In North Sea seabed sediment the specific resistance may be assumed, Mud : 60-75 Ohm cm Clay : 75-110 Ohm cm Sand : 110-160 Ohm cm if no measurements are carried out. Free flowing seawater and seabeds consisting of sand or clay may be consideres as aerated, whereas muddy sediments shall be considered as anaerobic, particularly in the presence of organic matter with sulphate reducing bacterial activity.	

PROCEDURES ADOPTED IN DANISH/NORDIC PROJECTS	GUIDELINE RECOMMENDATION	DISCUSSION FURTHER STUDIES ETC.

9.4.8. Anode Fabrication and Installation

9.4.8.1. Anode Fabrication

Sacrificial anodes for marine pipelines are normally made from zinc or aluminium alloys. The corresponding potentials in seawater may be assumed to be -1.03 V (vs. Ag/AgCl) and -1.00V (vs. Ag/AgCl), respectively.

Zinc anode alloy should as minimum confirm to the composition stated in U.S. Mil-A-18001 H norm which is:

Al:	0.10-0.50%
Cd:	0.025-0.15%
Fe:	0.005% max.
Cu:	0.005% max.
Pb:	0.006% max.
Si:	0.125% max.
Zn:	remainder

For good castability the following zinc alloy composition is recommended:

Al:	0.15-0.30%
Cd:	0.04-0.06%
Fe:	0.002% max.
Sn:	0.001% max.
Cu:	0.001% max.
Pb:	0.004% max.
Si:	0.001% max.
Zn:	remainder

Zinc anode alloys are susceptible to intergranular corrosion at elevated temperatures, and should not be used at temperatures exceeding 50°C. Unless the anode is mounted outside a layer of pipeline insulation.

Temperature for zinc bracelet anodes mounted on pipe corrosion coat should be assumed to be 2°C lower than the pipeline product.

To reduce susceptibility to intergranular corrosion at temperatures above 35°C, the following zinc anode alloy composition is recommended.

<table>
<tr><th>PROCEDURES ADOPTED IN DANISH/NORDIC PROJECTS</th><th>GUIDELINE RECOMMENDATION</th><th>DISCUSSION FURTHER STUDIES ETC.</th></tr>
<tr><td></td><td>Aluminium : 0.10% - 0.20%
Cadmium : 0.03 - 0.06%
Iron : 0.002% max.
Copper : 0.005% max.
Lead : 0.006% max.
Silicon : 0.125% max.
Zinc : remainder

Aluminium anode alloys have a tendency to passivate in seabed sediment, a problem which is alleviated by indium activation. The following aluminium alloy is recommended:

Indium : 0.005% - 0.05%
Zinc : 2% - 6%
Iron : 0.13% max.
Copper : 0.01% max.
Silicon : 0.2 % max.
Aluminium : remainder

Other aluminium anode alloy compositions can be used provided sufficient potential and capacity can be documented.

The anode comsumption rate is the reciprocal of the faradaic capacity, which decreases with temperature for zinc as well as for aluminium.

At ambient temperature capacities of 750 Ahr/kg and 2200 Ahr/kg may be assumed for zinc and aluminium, respectively.

The anodes should be provided with adequate reinforcement, and electrical and mechanical bond between reinforcement and anode alloy should be ensured.

The reinforcements for bracelet anodes should be designed to shipment and hold anodic material during the design lifetime of the bracelet.

The reinforcement should be designed to allow cracks in any direction in the anodic material with dimensions descriped in 9.4.8.2. recommended standard of acceptance criteria.

The reinforcement should be designed from flatbar and/or circular section steel.

The anodic material should not be considered as a structural member of the anode.

Bracelet anodes should be cast to meet nett weight requirement and not to mould volume.</td><td></td></tr>
</table>

PROCEDURES ADOPTED IN DANISH/NORDIC PROJECTS	GUIDELINE RECOMMENDATION	DISCUSSION FURTHER STUDIES ETC.
Standard of acceptance criteria should generally follow the requirements of CCEJV/NACE: Draft Code of Practice: "Metallurgical and inspection requirements of sacrificial anodes for Northern European offshore applications". Dec. 1983 issue.	9.4.8.2. Recommended standard of acceptance criteria 9.4.8.2.1. <u>Chemical analysis</u> Each furnace melt or charge should be sampled at beginning and end of casting from the melt. The samples should be subject to analysis to prove compliance with the chemical composition limits of the alloy selected. 9.4.8.2.2. <u>Anode weight</u> Bracelet anodes should be cast to meet nett weight requirement and not mould to volume. Individual anodes of each type should be within +/- 3% of nominal nett weight, total contract weight should be -0%, +2% of nominal contract weight. 9.4.8.2.3. <u>Anode dimensions</u> Anode mean length should be +/- 3% of nominal or +/- 25 mm whichever is the more stringent. Bracelet anode innerdiameter tolerance should be -0/+5 mm. Bracelet anode wallthickness tolerance should be +/-4 mm. The straightness of the anode should be a maximum deviation of 2% of the anode nominal length from the longitudinal axis of the anode. 9.4.8.2.4. <u>Reinforcement position</u> Anode reinforcement location within the anodes should be within +/- 5% of the nominal position in anode width and length, and within 10% of the nominal position in anode depth. For bracelet reinforcements intentionaly close to innerdiameter surface should be minimum 5 mm embedded in anodic material.	

PROCEDURES ADOPTED IN DANISH/NORDIC PROJECTS	GUIDELINE RECOMMENDATION	DISCUSSION FURTHER STUDIES ETC.
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	9.4.8.2.5. <u>Surface irregularities on the Anode Casting</u> Shrinkage depressions shall not exceed 10% of the nominal depth of the anode as measured from the uppermost corner to the bottom of the depression. For bracelets shrinkage depressions shall not exceed 1/3 of the wall thickness for half shell type bracelets or 20 mm, whichever is the less. Casting surface irregularities shall be fully bonded to the bulk anodic material. Not more than 1% of the total surface of the anode casting shall be contaminated with non-metallic inclusions visible to the naked eye. Cold shuts or surface laps shall not exceed a depth of 10 mm or extend over a total length of more than 3 times the width of the anode. On bracelets, where proper designed reinforcement steel intentionally is close to innerdiameter surface, cold shuts or surface Laps shall not exceed the depth to the reinforcement steel and not extend more than 1,1 time the width of the reinforcement steel member exposing max. 5% of the reinforcement steel member surface. All protrusions detrimental to the safety of personnel during handling shall be removed. Reduction in cross-section of anodic material adjacent to the emergence of reinforcements shall not exceed 10% of the nominal anode cross-section. 9.4.8.2.6. <u>Cracks in cast anodic material</u> Even with a good foundry practice particular compositions of anode alloy suffer a degree of cracking.	

PROCEDURES ADOPTED IN DANISH/NORDIC PROJECTS	GUIDELINE RECOMMENDATION	DISCUSSION FURTHER STUDIES ETC.
	Within the section of sacrificial anodic material , wholly supported by the reinforcement, transverse cracks are permitted with a maximum width of 5mm and unlimited length and depth, and a maximum of 10 cracks per anode. Small close cracks shall be taken as one crack. Cracks with maximum 0.5 mm width shall be ignored. Longitudinal cracks on the external active anode surface shall not be permitted, except for bracelets with proper reinforcement design and in final "topping up" metal. Anodic material shall not be considered as a structural member of the anode. 9.4.8.2.7. <u>Anode internal defects</u> For bracelet anodes with proper reinforcement design and cast to nett weight requirement, voids gas holes/pockets are insignificant. The sum of reinforcement area in contact with voids, gasholes/pocket should not exceed 5% of the total cast in reinforcement area. 9.4.8.3. <u>Installation</u> The anodes should be mounted securely on the pipe, and protected against mechanical damage during handling and installation. Each bracelet anode should normally be connected to the pipe by two attachments made by manuel welding, thermite welding or other qualified technology. The minimum distance between each attachment to the pipe and other welds should be 150 mm. Manual welds for electrical connections should be made on doubler plates welded directly onto the pipeline by a qualified welding procedure. Thermite welding should be performed according to a qualified procedure. A minimum of three test welds should be examined for bond, copper penetration and hardness. The maximum allowable copper penetration is 0.8 mm and 0.3 mm for pipelines and risers, respectively. The hardnesses should be within the limits specified for the pipeline system. The spacing between anodes should be sufficiently close to secure protection, and normally no more than 120 m.	

Tilmelding til VBS's seminar om DANSK MANUAL FOR SØLEDNINGER den 19. september 1985.

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