Robust Material Qualification for Arctic Applications

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ABSTRACT
Oil and gas exploration and production is moving into arctic areas. The reduction in ice-covered areas has rendered northern routes more advantages and in addition it is anticipated that as much as 25% of the undiscovered oil and gas resources can be found in the Arctic.

There is a lack of rules and standards that provide guidelines for material selection and qualification of materials for offshore and onshore structures in Arctic areas. Some actions have been taken to develop new standards e.g. ISO19906 Arctic Structure, however the guideline does not specify material requirements except for the statement that material shall have adequate toughness in order to behave ductile at low temperature. Material related standards like EN10225, API 2W and Norsok are not developed for low temperature applications and are generally applied for service temperatures down to -10°C (Norsok covers down to -14°C). For lower temperature, it is up to the designer to show fit for purpose of the selected material.

Hence, one major challenge for designers is to specify adequate toughness requirements at an early stage of the design process when material is ordered, since limited design analyses have been carried out. Due to uncertainty in the design requirements very stringent requirements are often put on the CTOD value, leading to unnecessary project costs or delivery problems for steel manufacturer or fabrication yard.

This paper will discuss factors that influence the required CTOD toughness value at an early stage of a design process. The guidance and topics discussed in this paper is based on the findings and learning’s from the five year Arctic Material research project run by SINTEF and supported by The Research Council of Norway, oil companies and suppliers. The main goal of the project is to establish criteria and solutions for safe and cost-effective application of materials for hydrocarbon exploration and production in arctic regions. One main task for the project is to carry out material and toughness testing of carbon steel at -60°C in order to qualify important material parameters. In addition to steel, non-metallic materials like polymers, different coatings, seal materials and composites are addressed by this research project.

KEY WORDS: arctic material, brittle fracture, toughness.

NOMENCLATURE
CTOD Crack Tip Opening Displacement (crack driving force and toughness parameter
LAST Lowest Anticipated Service Temperature
ECA Engineering Critical Assessment

INTRODUCTION
There is a lack of rules and standards that provide guidelines for material selection and qualification of materials for offshore and onshore structures in Arctic areas. Most of the offshore construction steels are purchased according to EN 10225 “Weldable structural steels for fixed offshore structures technical delivery conditions” which only provide requirements for Charpy values. No guidelines on CTOD toughness values are provided. For designers it can be challenging to decide the adequate CTOD requirements at an early stage when material is ordered, since limited design analyses have been carried out. Due to uncertainty in the design requirements very stringent requirements are often put on the CTOD value, leading to unnecessary project costs or delivery problems for steel manufacturer or fabrication yard.

This paper will discuss factors that influence the required CTOD toughness value at an early stage of a design process. The guidance and topics discussed in this paper is based on the findings and learning’s from the five year Arctic Material research project run by SINTEF and supported by The Research Council of Norway, oil companies and suppliers. The main goal of the project is to establish criteria and solutions for safe and cost-effective application of materials for hydrocarbon exploration and production in arctic regions. One main task for the project is to carry out material and toughness testing of carbon steel at -60°C in order to qualify important material parameters. In addition to steel, non-metallic materials like polymers, different coatings, seal materials and composites are addressed by this research project.