Well Integrity

What is well integrity?
Well integrity means “Application of technical, operational and organizational solutions to reduce risk of uncontrolled release of formation fluids throughout the life cycle of a well.” (NORSOK D-010)

A study carried out by the Norwegian Petroleum Safety Authority (PSA) in 2006 revealed that 18 percent of the production and injection wells on the Norwegian shelf suffered from some sort of weakened integrity.

Well barriers
A well barrier is a pressure-containing envelope that prevents fluids and gases from flowing unintentionally from the formation into another formation or to the surface.

The primary well barrier shall contain the fluids and gases at all times during the well’s life cycle, and under all load conditions.

The secondary well barrier shall contain the fluids and gases in the event of a breach of the primary well barrier. The secondary well barrier is hence a back-up to the primary barrier.

Overall well barrier functions
1. Prevent any major hydrocarbon leakage from the well to the external environment during drilling, normal production, and well operations.
2. Prevent hydrocarbons from escaping from the well and into subterranean formations.
3. Shut in the well on command during an emergency shutdown situation and thereby prevent hydrocarbons from flowing from the well.

Well barrier requirements
The following requirements may be deduced from the regulations given by the Norwegian Petroleum Safety Authority (PSA):

1. At least two independent and tested barriers shall, as a rule, be available in order to prevent an unintentional flow from the well during drilling and well activities.
2. The barriers shall be designed so as to enable rapid re-establishment of a lost barrier.
3. In the event of a barrier failure, immediate measures shall be taken in order to maintain an adequate safety level until at least two independent barriers have been restored. No activities for any other purposes than re-establishing two barriers shall be carried out in the well.
4. The barriers shall be defined and criteria for (what is defined as a) failure shall be determined.
5. The position/status of the barriers shall be known at all times.
6. It shall be possible to test well barriers. Testing methods and intervals shall be determined. To the extent possible, the barriers shall be tested in the direction of flow.

Authorities
- Petroleum Safety Authority (PSA) Norway
- Health and Safety Executive (HSE) Offshore Oil and Gas (UK)
- Bureau of Safety and Environmental Enforcement (BSEE) USA
- NOPSEMA, Australia

Standards and guidelines
- NORSOK D-010: “Well integrity in drilling and well operations”
- API RP90: “Annular casing pressure management for offshore wells”
- NOPSEMA-GL0936: “Management of offshore well operations plans”
- NOG 117: “Recommended guidelines for well integrity”
Analytical approaches

- Barrier schematics (mainly for illustrative purposes, see NORSOK D-010)
- Barrier diagrams (can be transferred into fault trees for quantitative analysis)
- Bayesian networks (mainly for causal analysis)
- Event tree analysis (suitable for analysis of stepwise barrier activation, e.g., BOPs)
- Procedure HAZOPs (especially for work tasks in drilling and well interventions)

Information sources

- NOG (2012): "An introduction to well integrity"
- Wellmaster Well Performance Analytics (ExproSoft)
- Vignes, B. (2011): "Contribution to well integrity and increased focus on well barriers from a life cycle aspect" (PhD thesis, University of Stavanger)