Structural Integrity: Materials Testing
Toughness Testing

Here we can see a fatigue crack being grown in a sample prior to testing. A thin starter notch has been introduced by wire cutting, and the crack is grown from the notch by cyclic loading of the sample in bending. Loading the sample like this ensures that the maximum stress is at the tip of the notch, so that is where the fatigue crack initiates and grows.
The circular depression you can see is an indent on the surface which helps to ensure that the fatigue crack is straight, through the thickness of the sample.
Once the crack has grown the toughness test can be performed. This sample of pipeline steel will be fractured in bending. An increasing load will be applied, and the response of the crack is monitored by a displacement gauge fixed across the mouth of the crack.
The specimen is located against a pair of bend rollers which are lowered into place. Then once the test is underway an upward force below the specimen will place it into 3-point bending as the whole specimen is forced up against the two bend rollers.
In this case the toughness is required at a temperature of minus 10 degrees Celsius, which is the operating temperature of the material when used in the pipeline. The sample is cooled using the vapour from a bath of liquid nitrogen poured over cotton wool. The test will begin when the sample is within two degrees of the desired temperature.
The load is applied, and the displacement gauge monitors the opening of the crack. Initially the response is elastic, but soon the crack tip plastic zone begins to grow.
As the test progresses, the fatigue crack can be seen to open.
Until eventually the sample fails.
The data from the test is used to give a measure of toughness, by the crack opening displacement at failure.
Finally the crack can be broken fully open to allow a detailed examination of the different surfaces.