Structural Integrity: Materials Testing
Damage Analysis

Anthony Horn
There's some gouging damage that happened during the installation of the pipe, uhm, and the customer's been asking us for advice, whether or not it's safe to operate the pipe with this gouging damage there. Uhm, so really what, what I'd like to do is to, uh, run through the inputs, uhm, and just have a look at the fracture analysis.

Adam Banister
Okay, well, what we can do, we can go through the different input screens. To start with, you said it's a pipe, is that with a longitudinal defect?

Anthony Horn
That's correct, it's a longitudinal defect, uh, and it's on the outside of the pipeline.

Adam Banister
Right, so we've got the standard solution there for that geometry. The, the other details that we'll need just to, to check we've got the right values, is for the flaw dimensions and geometry?

Anthony Horn
Yes.

Adam Banister
Uh, we've got wall thickness of 20 mil.

Anthony Horn
Yes, 20 mil thick pipe.

Adam Banister
Right and 254 mil radius?

Anthony Horn
That's right.

Adam Banister
Okay. Uh, obviously the critical parameter in this case is the flaw height?

Anthony Horn
Yeah, now that flaw height's come from, uh, non-destructive testing techniques at 2.2 mil depth.

Adam Banister
Okay, uh, so we've got everything we need for the geometry side. If we move on to the stress side, what we'll need is the, uh, with it being a longitudinal flaw, we'll need the hoop stress that's operating in the pipe.

Anthony Horn
It's, it's quite a low pressure pipeline. I mean it comes out at 38 megapascals.

Adam Banister
Right, so that sets that, that value, that value is current and then the residual stress side, is it, did we use zero residual stress or?

Anthony Horn
Well, in this case, the gouge is quite close to the weld, uhm, so even though it's impairment material, we're assuming a worse case scenario of the maximum possible residual stress left over from welding.

Adam Banister
Yeah, that's equal to yield stress … [talking together]

Anthony Horn
So that's correct.

Adam Banister
And the tensile properties, we need those at the, uh, operating temperature, which, I believe, is it minus 10?

Anthony Horn
It's minus 10; that's correct.

Adam Banister
So we've got those values in there, uh, that's 323 megapascals, is that the right value?

Anthony Horn
Hmm, yeah, yeah.

Adam Banister
Okay. Uh, and then the toughness, uh, you've just had some tests from…?

Anthony Horn
Yes, from the, from the testing, we've got a CTOD value of 0.412.

Adam Banister
Okay.

Anthony Horn
Okay?

Adam Banister
I think that gives us all the, all the input parameters, so if we just run through that, that first case and look at the failure assessment diagram. You can see here the initial analysis point, uh, well within the safe region of the failure assessment diagram locus, that's a good, a good position to be starting from…

Anthony Horn
Yeah, that's good.

Adam Banister
…uh, quite low down there.

Anthony Horn
Could we have a look at varying some of the input parameters to see what effect that has on the assessment points?

Adam Banister
Yeah. The first one we should probably look at is the primary stress…

Anthony Horn
Hmm.

Adam Banister
…where there's probably an operating stress and a fault stress.

Anthony Horn
Hmm.

Adam Banister
If we just look at increasing the stress by maybe typically a factor of three, uh, so put in a 100 megapascals there and see where that brings us. So you can see, it's still, still in, well in the safe region…

Anthony Horn
Hmm.

Adam Banister
…uh, but it's moved up on both the LR and the, uh, root delta R axis.

Anthony Horn
Hmm, okay. Could we look at the effect of increasing the flaw depth on the results?

Adam Banister
Probably a good thing to look at because if they're using ultrasonics then there might be quite some variability in that.

Anthony Horn
Yeah.

Adam Banister
So if we keep that, keep that high stress to a 100, originally 2.2 so…

Anthony Horn
Yeah, if we, if we double it to 4.4.

Adam Banister
And you can see there that it's, it's starting to move up significantly on the fracture axis now.

Anthony Horn
Okay. Can we double, double the depth again, up to 8.8?

Adam Banister
Yeah, increase that to 8.8…

Anthony Horn
Would that be enough to cause failure?

Adam Banister
Approaching half the wall thickness now, and you see this time it's gone into the, into the failure region, the FAD.

Anthony Horn
Could we calculate the critical depth of flaw necessary to cause failure?

Adam Banister
Yes, we can run here the critical parameter analysis, so we'll select flaw height there, uh, and put in our starting value. And then if we, if we run that, it'll give us here critical parameter, so 7.6 millimetres is the critical flaw depth.

Anthony Horn
So, you'd only get failure if you have three times as high stress and three times as deep defect?

Adam Banister
Yes, that will take you up to the, onto the failure diagram. Well, you can see there, the critical parameter brings you out actually onto the line.

Anthony Horn
So the customer advice, whether or not this gouge has compromised the structural integrity.

Adam Banister
Yeah, there's a, factor of safety on both stress and the, and the flaw depth.