From: Knox, Tom

Sent: Thu Jul 01 13:57:26 2010

To: Martin, John JW

Cc: Webster, Simon

Subject: RE: Possible erosion of the bursting disc holders

Importance: Normal

John,

Thanks. I don't think the R&M boys can help, I have spoken to them but they have no model and can only provide guidance on flow rates above which erosion occurs but we are talking about long term so low rate erosion. I will try to see if I can get a calculation of flow rate through the bursting disc.

Tom

Tom Knox

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From: Martin, John JW
Sent: 01 July 2010 14:44
To: Knox, Tom
Cc: Webster, Simon
Subject: RE: Possible erosion of the bursting disc holders
Importance: High

Tom,

My input data, as promised:-

Nozzle ID 1/8" (0.125")

Throughput 750 barrels per day (I calculated this as close to 175m/s!)

Solids Content 367 lbs/barrel (so 275,000 lbs/day)

Solids Barite:-

Particle size range fro 10 to 170 micron (see Matt's report)

Barite Density: 4480kg/m^3

Liquid

Density:- 1635kg/m^3

Viscosity: 68cp (10cp used for erosion modelling but I didn't find it made much difference in this case)

Let me know if you need anything more.

Best Regards

John Martin

Advisor, Materials and Corrosion

EPTG, Sunbury

From: Martin, John JW

Sent: 01 July 2010 14:32

To: Hill, Trevor

Cc: Lockett, Tim; Espiner, Richard; Webster, Simon; Knox, Tom

Subject: RE: Possible erosion of the bursting disc holders

Importance: High

Trevor,

I located a Report by Matt Tabinor that gave me the other input data I needed (see attached), assuming this is correct/current. Unfortunately when I put this together with the data you have provided into SPPS the program crashes. The problem is that SPPS was developed for piping systems such I have to enter the orifice diameter as a pipe internal diameter. The program gives a warning below 0.5" internal diameter and gives nonsensical values with the 0.125" (1/8") diameter required here. I could 'fool' the program into

working by picking a 0.5" internal diameter and matching the velocity but I fear this would stretch the capabilities of the program too far. I am already using a far higher solids loading compared to what the program was developed for. All I can offer at present is a qualitative answer which is that with 750 bbls/d through an 1/8" diameter orifice I calculate a superficial fluid velocity of nearly 175m/s (NB. is this credible?). With such a high velocity and a high solids loading (given as 367 lbs of barite per barrel in Matt's note; such there is over 10,000lbs/hr of solids going through the orifice) I think it has to be assumed there is a credible risk of a high degree of erosion damage occurring in a short period of time (FYI with the exceptional case of 0.5" piping and a 1.5D elbow SPPS gives an erosion rate equivalent of well over 100 inches per hour! However, as indicated, I could not vouch for the validity of this value or its relevance to the present case). I think our best chances of success lie in either information from folks who use nozzle technology (although I would be surprised if they ever experience 175 m/s or a 'soft' nozzle material such as 316 stainless steel) or from the CFD modelling (which Simon should be able to provide an update on for the meeting).

Hope this helps, sorry I am unable to be more definitive.

Please treat any calculations as preliminary. I have checked my inputs several times but there is room for errors to be made without throurough checks.

Best Regards

John Martin

Advisor, Materials and Corrosion

EPTG, Sunbury

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Registered in England and Wales, number 305943.

<< File: Top Kill Erosion Analysis.doc >>

From: Hill, Trevor

Sent: 01 July 2010 11:55

To: Martin, John JW

Cc: Lockett, Tim; Espiner, Richard; Webster, Simon; Knox, Tom

Subject: RE: Possible erosion of the bursting disc holders

John

Thanks so far... and I have seen the out of office reply from Samir...

I have added much of the requested information into the note at the bottom. Regarding disc holder orientation then please use whichever in your judgement would give greater wastage. Our assumption at the moment is that a maximum of 6 discs may have failed, but that it is not possible to fail all 12.

If anything is not clear or sufficient, please would you call me on my mobile... I will be in a meeting at 3pm your time in which the status of this will need to be presented, so an update on progress by 2:30 would be helpful... any initial SPPS based view, and timeline for further more detailed work... hopefully Bryan can give the solids information you need.

Regards

Trevor

From: Martin, John JW

Sent: 01 July 2010 10:34

To: Espiner, Richard; Webster, Simon; Hill, Trevor; Knox, Tom; Cook, Howard H

Subject: RE: Possible erosion of the bursting disc holders

Richard,

Yes the holder geometry (at least in the direction of flow) would be different. This might affect the CFD modelling results.

Best Regards

John Martin

Advisor, Materials and Corrosion

EPTG, Sunbury

From: Espiner, Richard

Sent: 01 July 2010 10:30

To: Martin, John JW; Webster, Simon; Hill, Trevor; Knox, Tom; Cook, Howard H

Subject: RE: Possible erosion of the bursting disc holders

John

For your three modelling cases - is there any difference between the case with 6 bursting discs failed and the case with 6 collapse discs failed? My understanding from yesterday was that these were arranged symmetrically around the pipe so these cases may in fact be the same. Unless the holders are installed in different orientations for each i.e. nozzles facing in/outwards?

Richard

From: Martin, John JW

Sent: 01 July 2010 10:21

To: Webster, Simon; Hill, Trevor; Knox, Tom; Cook, Howard H; Espiner, Richard

Subject: Possible erosion of the bursting disc holders

Importance: High

Folks,

I have been giving some thought on how we could get a handle on the possible erosion of the 316 stainless steel bursting disc holder, if the bursting discs have been breeched and there was flow of the mud through the holders during the top kill operation (NB. Trevor please confirm this is the correct focus for the study). This is correct... it is to look at the effect of several hours of mud flow, and 70 days of lower rate hydrocarbon flow

Unfortunately nozzle erosion is not an issue we have addressed in the past such this type of geometry configuration is not incorporated into our erosion models. I have also trawled the on-site information sources I am aware of and have not, to date, come up with any models that would be suitable. Tom is also following up with the folks in R&M to see if they have any data/models for nozzle erosion since some of their operations (e.g. catalyst circulation) involve pumping highly erosive fluids through nozzles.

Therefore I would recommend the following actions:-

(i) Get a CFD erosion model of the two bursting disc holder configurations developed (NB. Simon, Samir could do this in fairly short order given the drawing in the e-mail you forwarded; is this something you could follow up with him?). Unfortunately it would not be possible to validate such a model within a short time but it should give us an 'order of magnitude' answer - we could also do the normal benchmarking study against SPPS using a 1.5D elbow to give a little more confidence in the answer. Yes please to both

(ii) Collect the necessary data and run the SPPS Erosion Model for the available geometries. This should at least give some idea of the possible magnitude of the erosion event. Please would you do this asap for the information given below...

In the meantime I will continue my trawl to see if there is anything available on nozzle erosion modelling and we will see what comes out of Tom's discussions with R&M.

Regards the study, I need to make a number of assumptions and would be interested in any comments:-

- It will be assumed that the bursting disc has been completely destroyed/removed from the holder such only the bursting disc holder remains. Yes, starting with the 0.125" ID
- For the number of 'holes' (i.e. bursting disc failures) three cases will be assumed:-
  - (i) All 12 bursting discs have failed No
  - (ii) The 6 'burst' protection discs have failed Yes
  - (iii) The 6 'collapse' protection discs have failed Yes
  - (iv) Any others? Rates below are given per disc
- For the erosion modelling I will need to know:-
  - Total throughput of mud in barrels See next comment...
  - Rates at which the mud was pumped (some sort of timeline would help if this varied) and over what period There was some variation through the three top kill runs, but as a starting point please assume initially 750 bbl/d per disc driven by a pressure drop of 2000 psi for a total of 8 hours - that rate per disc will increase with any orifice opening, but a quick estimate of initial rate of wastage is what we would like, with a sensitivity to flowrate
  - Mud Properties:- given the information provided yesterday then the additional input on barite properties (particle size, density, shape) would need to come from Bryan
    - Liquid viscosity (cp) and density (lb/ft^3) at the in-situ temperature Tim Lockett has an estimate of some of this, though we do not yet have temperature dependency
    - Solids (barite) loading (lbs/barrel) Mud density is 14.2 pounds per gallon
    - Barite properties (particle size, density, shape)

    (Trevor is Bryan Chambers best placed to provide this information?)

Finally we need to be mindful that the damage mechanism might be abrasive wear (liquid sandpaper if you wish) rather than erosion so need to bear this in mind. I will try to follow up on this aspect (e.g. there may be some abrasive wear models available from the MARIOS Project we could use). If we can find a suitable erosive wear model hopefully this could be incorporated into the CFD model as well.

Best Regards

John Martin

Advisor, Materials and Corrosion

EPTG, Sunbury