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CERTIFICATION OF ORIFICE PLATES

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CERTIFICATION OF ORIFICE PLATES.

I have been requested to talk about Certification of Orifice Plates. First I will take the opportunity to do some free company marketing, then a short section on the development and research there have been within this paticular field, and finally I will get around to the main topics of this session.

Since the various words and expressions in this business is developed in English it is essential that you have a clear understanding of the meaning of the words. A dictionary does not always give you the correct answer. This leads me to a episode I came across when I was reviewing a metering procedure on behalf of a oil company. There I read a expression in Norwegian which puzzeled me, and what it said I will try to visualize with this drawing.
In the English original text it said "-- Custody Transfer of Crude Oil--".

Con-Tech a.s is a Norwegian independant company which has specialised within Custody Transfer Measurement and amongst other we offer services such as consultants, prover and meter calibrations and Orifice Plate Certification.
To my knowledge we are, as of today, the only Norwegian Company recognized by NPD and DoEn to do ISO certification of Orifice Plates.
I can not show you a offical paper confirming this but if you inform NPD that you intend to use us as Plate Certifiers they will tell you (hopefully) that they have no objections to such a arrangement.
This recognition is under constant evaluation and we have frequent visitors from NPD when doing certifications, checking our performance.
If they are not satisfied I think you will be the first to know.
Another advantage it gives to have an independant company to do the certification of sales meter plates, is the integrety it gives the operating company versus its partners in the field.

HISTORY - RESEARCH

Within all companies that produces oil and gas there is a ongoing struggle to improve the systems and methods for operating and maintaining the sales meters. This struggle was intensified with the increasing prices for petroleum products, because the sales meters is one of the companys major cash register and should be treated accordingly.

Laboratories and institutions was assigned projects with the aim to improve the metering systems and reduce the uncertainties connected with the metering.

Brithis Gas did some research on the problems with orifice plate buckling and they experienced, on a 8 inch meter with a 0.7 beta and a half inch deflection, a flow under-registration of 14%. And with a quarter inch deflection, a error of 3%.

Foreign matter in the meter run, such as bolts, nuts, tools and welding rods, will also cause a metering error, but not of the magnitude of a buckled orifice plate. It is in the region of up to 1.5% under-registration. This particular problem decreases as a function of time from start-up and can be avoided with frequent meter run inspections after start-up.

Another and more serious type of meter run fouling is the presence of liquid. In the worst cases an over-registration of 50% can occur. However, in a properly designed meter run every effort are taken to avoid the presence of liquid, but mistakes can happen and they do happen. A example of that is a fuel gas metering run in the North Sea where the Orifice Fitting is the lowest item of the system and where it had become a operational procedure to drain the meter run at fixed intervals.

The last item to be mentioned in this section, that has a significant effect of the accuracy of flow measurement through orifice plates, is the sharpness of the upstream edge of the plate bore. Careful attention must be given to the condition of this edge or serious errors can result.

Some years ago, National Engineering Laboratory in Glasgow, did some research on the various methods available for assesment of the condition of the plate edge. The three methods they looked into was the reflection of a light beam, epoxy resin casting and lead impression. Their conclusion to the test was that the optical method at present was not suited for accurate measurements on small diameter plates, but it could be used to examine large diameter orifices for burrs or excessive rounding. The NEL casting method takes the longest time (two days for the completion of a plate) but since each cast closely follow the edge profile, accurate results is obtained. This method is the best to determine the shape of re-entrant profiles. The lead foil impression is much more quickly to complete, and produces as accurate results as the NEL casting method. But it suffers from the disadvantage that it will not accurately define certain re-entrant profiles.

TRACEABILITY

Now I think it is about time to switch to the main topics for this session, namely Certification of Orifice Plates in accordance with ISO 5167.

When we decieded to set up a laboratory for certification of orifice plates, the most important issue to be dealt with was traceability. That is, how could I prove to a client that his 200 millimetre orifice bore really was 200 millimetre and not 201 or 199.5 millimetre? The answer to that was of course certified gauge blocks. Since we aimed against the sales gas orifice plates, we bought laboratory quality (ISO grade 00). We maintain the traceability by sending the gauge blocks to recertification on a annually basis, and any piece not meeting the specification are changed out with a new.

We of course purchased the necessary micrometers, instruments and tools, and was ready to start certifying.

But then we faced a new problem. NPD and our future clients asked what plans we had for demonstrating and convincing them that we knew what we were doing, and the accuracy of our work.

We had to arrange for a test by re-certifying some orifice plates and compare results. As some of you knows we passed the examination.

The first thing that happens when we recieve an order for certifying plates, is that we, by telex, informs the parties involved on which date the certification is going to take place.

Then we assign a job-number to the order and reserve the certificate numbers required.

After the plates are recieved and unpacked, they are given a visual inspection for damages and then placed in the lab for temperature stabilization. The work sheets are filled in and the various limits calculated. The proper gauge blocks are assembled and the instrument for the orifice bore measurement are set up. The micrometers to be used are checked against gauge blocks in the actual ranges.

PLATE FLATNESS

I normally starts the certification by checking the plate flatness. the upstream face of the plate is placed towards our Diabas stone table and feeler gauges inserted between the plate and stone. The found values are noted on the work sheet. If the plate has a vulcanized seal, a straight edge ruler is placed across the upstream face instead. If the deflection is zero the plate will be checked along the outside for bukling against flow direction. In such cases notes will be made in the remarks colum. The average deflection is calculated and also the static's persentage of the total (static/dynamic) deflection. Discussions is still ongoing on how large percentage part to be allowed for static deflection.

PLATE ROUGHNESS

The next item to be checked is the plate roughness. The upstream face is checked for schratches or groves, and if nothing special is found, three spots is choosen at random.

The measurement is done with an electronic instruments which displays the R_a (Roughness average) in micrometers or microinches. In addition the trace is printed out as documentation for the findings.

The roughness meter is checked periodically for accuracy. This is accomplished by the use of a roughness standard, and the instrument adjusted if required.

I would like to point out that waviness is not considered roughness by the instrument, and therefore not reflected in the roughness average value displayed.

Full scale on the recording paper is normally 10 micrometers.

The maximum value found will be noted on the work sheet and a copy of the recordings will follow the certificate.

CONCENTRICITY

Another area where we can divide the allowed deviation into two sections is on orifice bore concentricity. A major part of the total deviation is put on the orifice plate carrier or fitting and a lesser part on the bore itself. No official decesion on the split between the two parts has been taken.

Our method of measurement for this section is by a digital vernier caliper, resolution 0.01 millimeter. The distance from the bore to the plate outside is measured at opposite positions and difference found. The average value is determined and calculated as percentage of the total allowed deviation. This percentage is also given on the certificate front page.

PLATE THICKNESS

The instrument used to measure the plate thickness is a micrometer caliper with a resolution of 0.002 millimeter. The thickness is measured about 20 millimeter from the bore at eight places and values noted on the work sheet. Four spots is choosen at random along the outside to check that the thickness and variations are within required limits. The micrometer caliper has a friction knob so that equal thightness is applied at all measurements.

EDGE THICKNESS

The method of measurement is by a depth micrometer with graduations in 0.01 millimeter.

The micrometer is placed against the upstream face of the plate and the stem aligned with the beginning of the beveled edge.

The alignment is by eyesight only and it is obvious that this is not a very accurate measurement. Variations less than 0.05 millimeter is difficult to detect, but with the good machining techniques we experiense, it is not often we register notable variations.

On plates not having a beveled edge or a vulcanized seal, precise measurements can be obtained taking into account any possible plate buckling.

ANGLE OF BEVEL

To measure the angle of bevel we use a bevel protractor with a resolution of 1/12 of a degree.

According to ISO 5167 the angle of bevel should be measured relative

to the orifice bore while the AGA-3 states that the angle should be measured relative to the upstream face of the plate. However, in practical certification we measure the "AGA-3" angle and then subtract from 90 degrees to get "ISO 5167" angle.
The angle is checked at four spots and average value noted on the woork sheet.

DOWNSTREAM FACE AND EDGES

The check here is visual only, and we do it when we recieve the plates. The reason for that is, if damages is discovered, we imediately can return the plate for further machining.

ORIFICE BORE

Our method of measurement of the orifice bore is by a electronic indicating instrument. Gauge blocks that equals the nominal bore of the orifice plate is assembled and the lenght of the indicating instrument is also assembled as close as possible to the same lenght. A note is made of the gauge blocks total lenght.
The indicating instrument is placed between the gauge blocks and the digital display on the electrinics is adjusted to zero, and so the pluss and minus sign shifts continously.
The display is normally set up to indicate one thousand of a millimetre, which is under our present conditions, the best accuracy we can claim.
The instrument is then placed in the plate bore, and by moving the handle, we search for the smallest number on the display. The value is taken down with special attention to either pluss or minus sign on the display. The displayed value is added or subtracted, depending on the sign, from the total length of the gauge blocks and the result noted on the work sheet.
This procedure is repeated three times through all the measurement stations.
Thereafter the indicating instrument is placed between the gauge blocks to get a verification of the zero reading on the digital display.
If a deviation occur, the instrument is re-zeroed and the whole procedure repeated.
However, if the deviation is a negative value it indicates that the instrument has been exposed to excessive heat from handling. Then the instrument has to be set aside for temperature stabilization.
When the instrument reads zero again, the metering procedure is repeated

and every effort is made to avoid excessive heat transfer.

EDGE SHARPNESS

The final item I will discuss is the measurement of upstream edge sharpness, and the method of measurement is by the lead impression method. The instrument utilized for this measurement is of our design.
By a linear movement at an angle of 45°, the lead foil is given an indentation about 15 to 20 hundreds of an millimeter deep. The depth is controlled by a micrometer head. A light alarm flashes when the lead foil gets in contact with the plate edge.
We have a set of lead foil clamps with numbering that corresponds with the measurement stations, so the above procedure is repeated seven times with different foil clamps.
Thereafter the foil clamp is placed under our microscope and a photograph taken with a polaroid camera.
The microscope and camera is so adjusted that the resulting magnification on the picture is 100 times. This can be verified by taking a picture of a object with known dimensions.
Information of certificate number, station number and job number is imediately noted on each picture.
After the pictures has developed, we compare the image of the orifice edge with a set of radius gauges, seeking for the best curve fit.
The size of the radius gauge is then divided by hundred and the result noted on the work sheet.
A copy of the pictures is a part of the certificate as documentation for the findings.
Due to the various edge profiles that occur it is not always easy and straight forward to determine the edge radius. In those instances we apply "the best curve fit" tecnique.
Viewing a picture of an impression you will always find the upstream face to the left and the orifice bore to the right.
Our experience so far, with respect to the quality of the norwegian machine shops, is that they do a exellent job. Out of about 150 certifications to date we have only rejected two plates with excessive edge roundness. Normally they are well within required limits.
That also applies for the other parameters we measure.

Finally we check through the various parameters measured to see if they are within ISO 5167 requirements. The findings are the noted on the certificate front page.

Con-Tech is continously looking for improvement of measurement methods and instruments in order to produce the best possible and reliable results.

Last month we completed the draft to our QA manual, and our various procedures are presently beeing adapted to the QA system.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.