ORKUSTOFNUN

Investigation and repair of a wellhead leak on geothermal well BO-2 at Bouillante

Sverrir Þórhallsson

Greinargerð SÞ-2003/02

Bouillante 08.05.2003

Investigation and repair of a wellhead leak on geothermal well BO-2 at Bouillante

1. INTRODUCTION

At the request of CFG, Mr. Sverrir Thorhallsson, Head of Engineering Dept. at Orkustofnun GeoScience Division traveled to Bouillante in Guadeloupe May 4-9 to inspect a steam leak on the wellhead of BO-2. This leak had recently been noted while the well was put back on stream after having been shut-in for about 10 months. This well had been the sole source of steam for the double-flash turbine at Bouillante for 13 years. The well was originally drilled in 1970, and has been in use since 1986. The reason for restarting the well at this time was due to outage of the new steam system that has supplied the old power plant since July 2002. The outage is due to the droplet eliminator in the HP separator breaking up into small pieces and falling to the bottom, due to heavy corrosion on the mild steel chevrons. The stainless steel 316 L wire mesh eliminator in the moisture separator by the new power pant did not show the same signs of deterioration.

The terms of reference (TOR) were outlined in an E-mail message from Mr. Herlander Correia of BRGM to Orkustofnun dated 2 May 2003:

a) The assessment of the BO2 wellhead 2002 repair, the problem identified pit and limited cracking of the weld on the repair packing.
b) Design of the repair "packing".
c) Supply of the packing material and the pin bolts.

2. ACTIVITY REPORT

May 4. Traveled via Paris Charles De Gaulle airport (CDG) to Guadeloupe where I was met by Mr. Herlander Correia, and Mr. Bernard Herbrich, Drilling Eng. I had checked two pieces of luggage, total 50 kg, through to Pointe à Pitre. No overweight chargers were applied as I was flying Business Class out of Iceland and Alizes Class from CDG. Upon checking in for Guadeloupe, I asked whether the luggage had arrived at AF in Paris, as I landed there 2 hr. earlier. It was confirmed that both luggage had arrived. In the departure lounge, I spoke to the gate agent and asked her to reconfirm that both pieces of luggage were on board. She said that the computer system showed only one baggage on board. I asked her to trace the luggage and insure that both were on board, but she said that could not be done and that I would probably find both pieces on the conveyor line upon arrival in Pointe à Pitre. This was not the case, and I was paged by the AF desk and given a fax from Paris stating that one of my pieces of luggage had been left behind and would arrive Wednesday evening. I came in Sunday evening. No reason was given why the 28 kg heavy box (fiberglass, like a camera case) containing the hardware (item c in TOR) that I was bringing along was not on the plane.

May 5. Mr. Bernard Herbrich picked me up to go to the power plant at 7:30 to meet Mr. H. Correia. I went to work with Mr. Herbrich improving the sketch that I had prepared 1 May in Iceland from the limited amount of information I had on the well (fig. 4), after Mr. Correia first contacted me 30 April (fig. 3).
It was decided that the work programme should be in the following order:

1. Seal the main leak.
2. Cure other minor external leaks on the wellhead, on flanges and expansion spool.
3. Identify any internal leaks in the well e.g. expansion spool or casing strings.

Then we went to well BO-2 to inspect it and take dimensional measurements. The original leakage had by then stopped completely by self-sealing and thus close visual inspection and measurements were possible (fig. 2). I noted that a spot to the left of where the main leakage had occurred showed early signs of a leakage where a bolt hole had been welded shut as part of installing the reinforcing collar on 9-5/8" in 2001. This spot is visible on the photograph sent to me 1 May by Mr. Correia (fig. 1). Closer inspection of the bolt hole by the main leak showing no crack visible on the weld, (as originally thought), brought up the idea that the leak might be a pin-hole in the weld over the bolt hole (fig 2). Mr. Herbrich took me to well BO-4 that has the same 9-5/8" pack-off as BO-2 (fig. 5). We confirmed that the press plate of the pack-off was dimensionally identical. It was thus clear that the original press plate of BO-2 had been welded to the 13-3/8" pack-off flange as part of the reinforcing work in 2001. The bolt holes had to be closed by welding, and the focus was on locating the leak in that area. I asked for die-penetrant testing of the welds to detect any cracks or holes. Mr. Herbrich arranged for this to be done next day (May 6) by the welding contractor COTUMER. In the evening, I sketched up a new ring patch to be welded over the old press plate to cover the old bolt holes, and also the weld of the reinforcing collar (fig. 7). The water seeping into the cellar of BO-2 was measured by Mr. Eric Lesne to have conductivity of 20 milliS/cm, and silica 170 mg/kg, confirming that this was local brackish groundwater and not deep reservoir fluid. This confirmed that there was not an underground leak from the well.

May 6. A three component die penetrant was applied by a welder from COTUMER, and it confirmed that a pinhole was in one bolt hole weld, and that no cracks or defects were in the main weld by the casing reinforcing collar (fig. 6). Mr. Herbrich and I also measured the annulus pressure between the 7" production casing and 9-5/8" casing, and were surprised to find that the annular pressure was only 3 bar-g and the WHP 14 bar-g at the same time (control room reading of pressure transducer). This meant that the 7" production casing and expansion spool were not leaking internally – good news. It also alleviated the concerns of the welders of welding the patch to the well under high pressure. Then we made a cardboard cut-out of the ring patch and had the welder approve the chosen dimensions and fit (OD 180 mm x ID 135 m), as the well casings are not exactly centered. We found a 40 mm thick steel plate by well BO-4, and it was decided to use it, but a 30 mm plate would have been thick enough. After lunch, the welder started fabrication of the patch and by 15:00 the welding started. By 18:00, two COTUMER welders completed the job (fig. 8). The leak on the wellhead of BO-2 was thus successfully repaired.

May 7. Today's activity was to seal other external leaks, although small, on flanges and on the expansion spool. Mr. Herbrich first tightened the flanges with a strike wrench and so the bolt heads would turn about 1/8 of a round (fig. 11). Then the wing valve stems were repacked and exercised; most were quite stiff initially. Finally, high temperature Teflon "rat shit" was injected into the expansion spool to energize the thread packing (fig. 9). Enough material (two full rods) was injected to conclude that some had passed the check valve in the head and into the expansion spool. The bled tap opposite the injection port was exercised and no fluid came out. The pressure release plug was retigthtened one turn more than before as there had been a definite leak on this port. A crack was detected once the scale deposits were removed from the expansion spool middle flange below the plug (fig. 15). This crack should be closely observed for signs of leaking. Some of the leaking may have been from this crack, although the most suspect area was the ring tool joint (RTJ) flange connection.

In order to confirm suggestions that the 9-5/8" casing was broken, the pressure in the second annulus (blue colour in fig. 3) would have to be the same as in the first annulus (green colour in fig 3). As the wing valve on the 13-3/8" casing head is the original one, and has been on the well for 32 years (or since 1970?), there were concerns that the pressure could not be measured due to the condition of the valve. Further inspection by Mr. Herbrich revealed that two studbolts on the pressure side of the wing valve were so corroded that only one-third of the stud was still there (fig. 13). Attempts to drive out the remaining bolt failed and it was thus decided to weld the flanges together in four places with four 20x20 mm rods (fig. 14). This job was completed late in the

afternoon. An experienced "hot-tap driller" had been located and would show up in the morning to inspect and then drill a 4 mm hole though the wing valve to install a pressure port that will allow the pressure in the outer annulus to be measured. I had a meeting with Mr. Herlander Correia, Mr. Bernard Herbrich, Mr. Claude Bannwarth, Mr. Claude Buglione, and Mr. Julien Cairo to go over what had been accomplished in the three days I had been in Bouillante, as I was scheduled to depart the following afternoon.
I informed them that the work outlined in the TOR had all been successfully accomplished. The work was carried out in the order originally laid out and there were now no known external leaks on the wellhead. Pressure measurements on the wellhead of 14.2 bar-g WHP (tan color in fig. 3) and in the first annulus of 2.7-3 bar-g (green on fig.3) moreover confirmed that the 7" production casing was without leaks and also the expansion spool. This was good news and now only pressure in the second annulus (blue on fig 3.) had to be measured to see what the condition of the 9-5/8" casing was. If that casing was also pressure-tight, the well was in the original design condition as far as redundancy is concerned and with a new wellhead and expansion spool. The old part of the wellhead had two stud bolts corroded away and the first 1 m of casing below the 13-3/8" casing head was the most suspect and set for outside corrosion. The well is 32 years old and has been the sole supplier of steam to the existing 4.7 MW plant. By bringing the well on stream very slowly and minimizing thermal cycling on the wellhead by keeping it hot when not in use, will minimize thermal stress. I told them that the items covered in this report, with the positive results in solving the known leakage problems with well BO-2, could influence the decision whether to use the well for a few more years or abandon it immediately. Such a decision will have to take into consideration many factors outside what was covered in the TOR during these three days and would rest with CFG.

May 8. Worked on completing this short report and handed a copy to Mr. Herlander Correia before departing to the airport shortly after lunch. Without his good cooperation, and especially from Mr. Bernard Herbrich, this work would not have been completed in such a short time and so successfully. I want to give special recognition to the foreman and welders of COTUMER for their excellent work and good ideas.

Bouillante, Guadeloupe
08.05.2003
(minor revision Reykjavik 13.05.2003)

Sverrir Thorhallsson

Att.
Appendix I – Figures 1-16

Appendix

Figures

Figure 1. Photograph of the leak on BO-2 wellhead sent to me May 1 (photo H. Correia)

Figure 2. Photograph of leak area on BO-2 when I arrived. The leak had stopped due to self - sealing when the wellhead temperature dropped and thus the annular pressure.

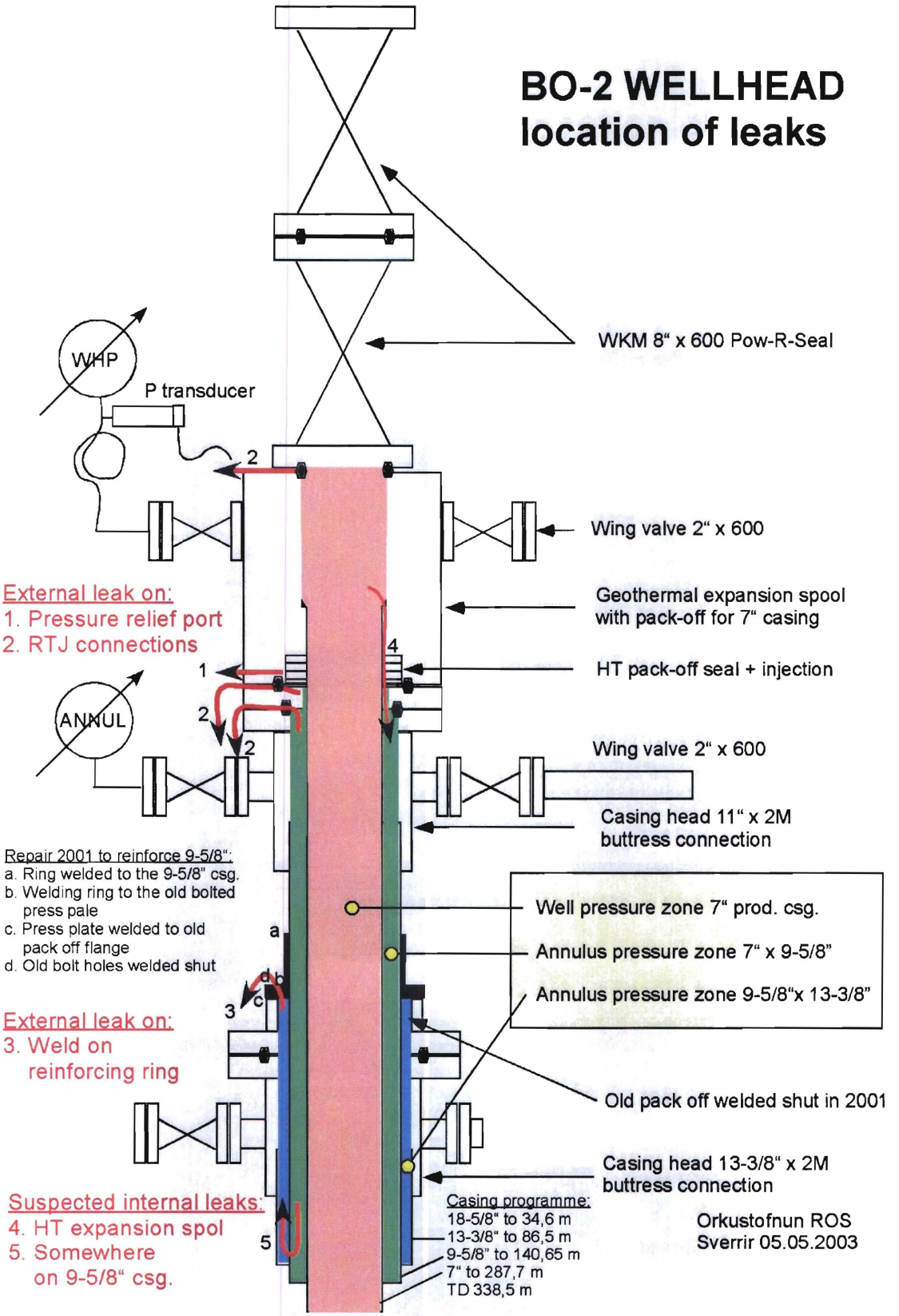

Figure 3. Drawing of BO-2 wellhead showing location of possible leaks and pressure zones.

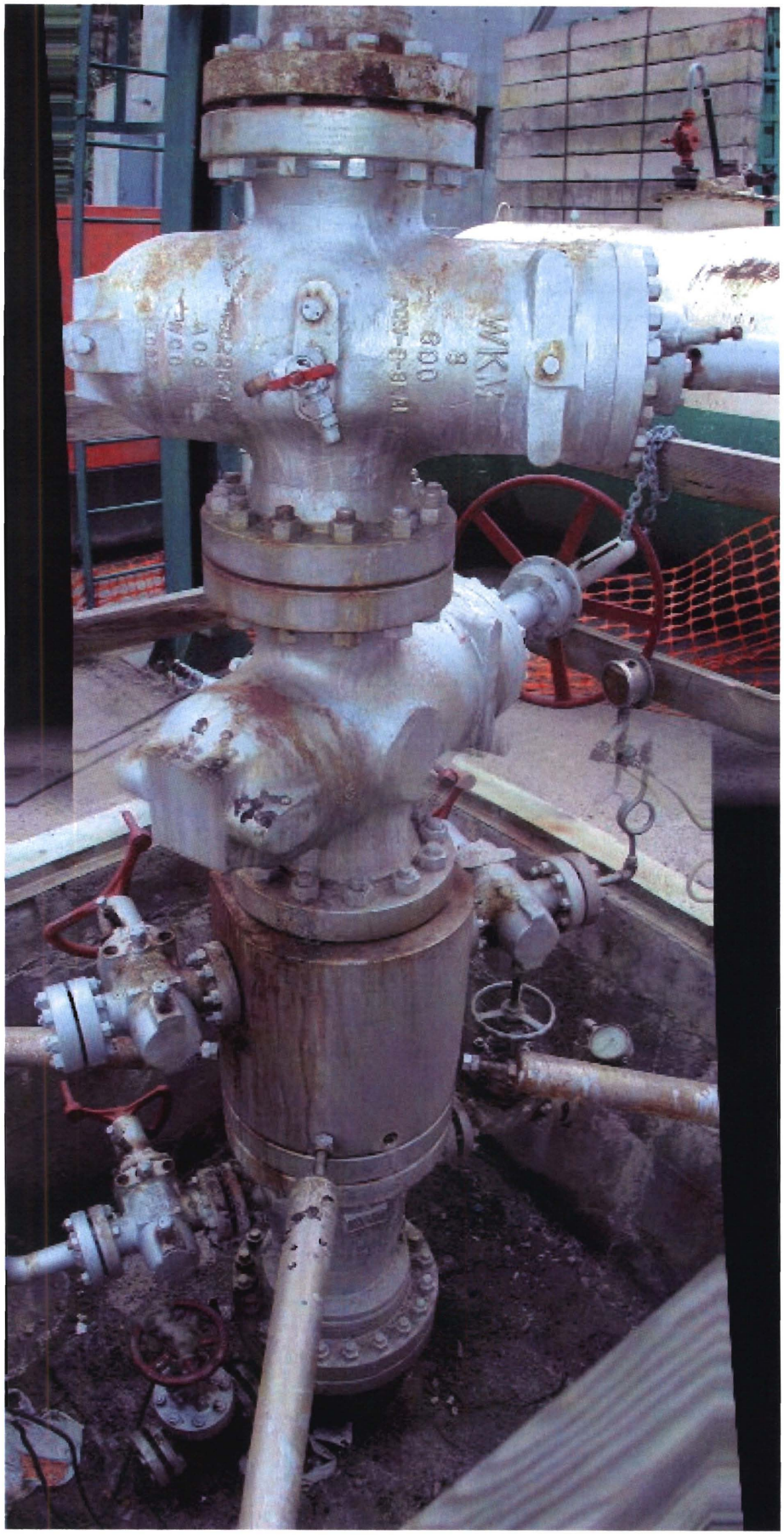

Figure 4. Wellhead of BO-2 in March 2003. The picture is stitched together.

Figure 5. Wellhead of BO-4 showing an identical seal as was welded shut when the reinforcing ring was welded to BO-2 in 2001. Note bolt holes on the seal pressure plate (upper row of bolts) that had to be closed by welding. A pinhole in one such weld caused the present leak on BO-2.

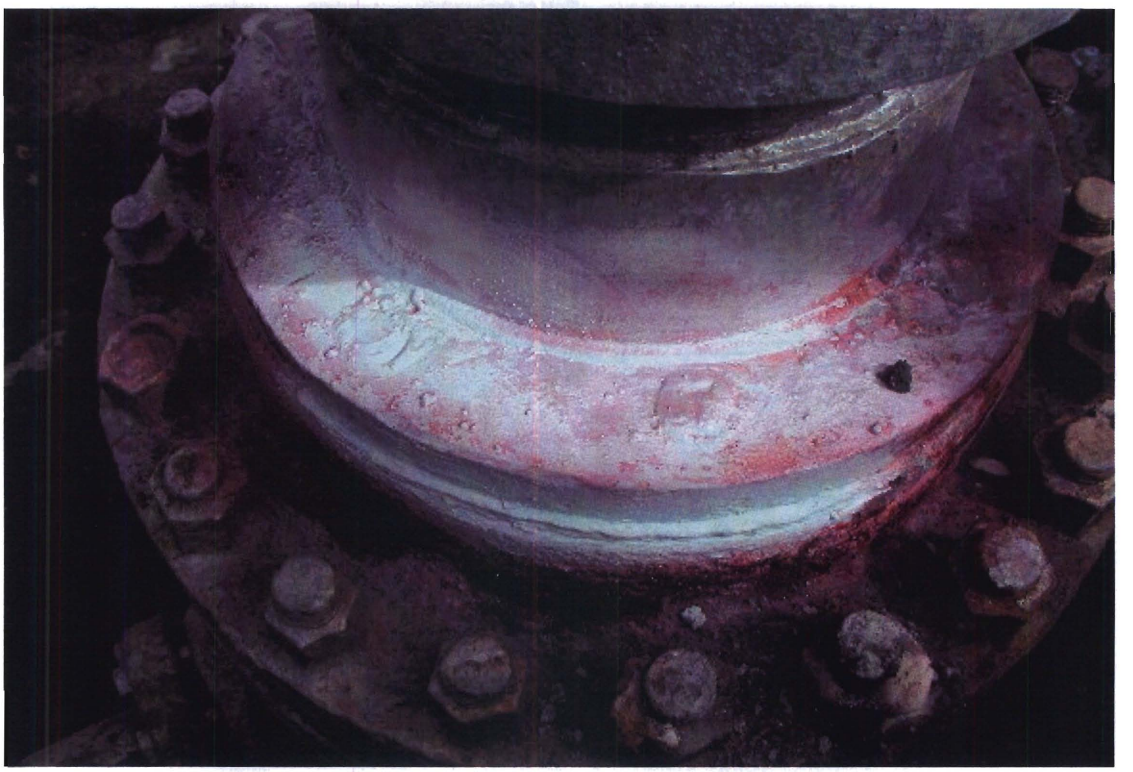

Figure 6. Die penetrant applied to welds on the wellhead of BO-2 where the leak occurred to identify cracks or holes. No welding cracks were detected, but a small pinhole in the weld covering one bolt hole showed up.

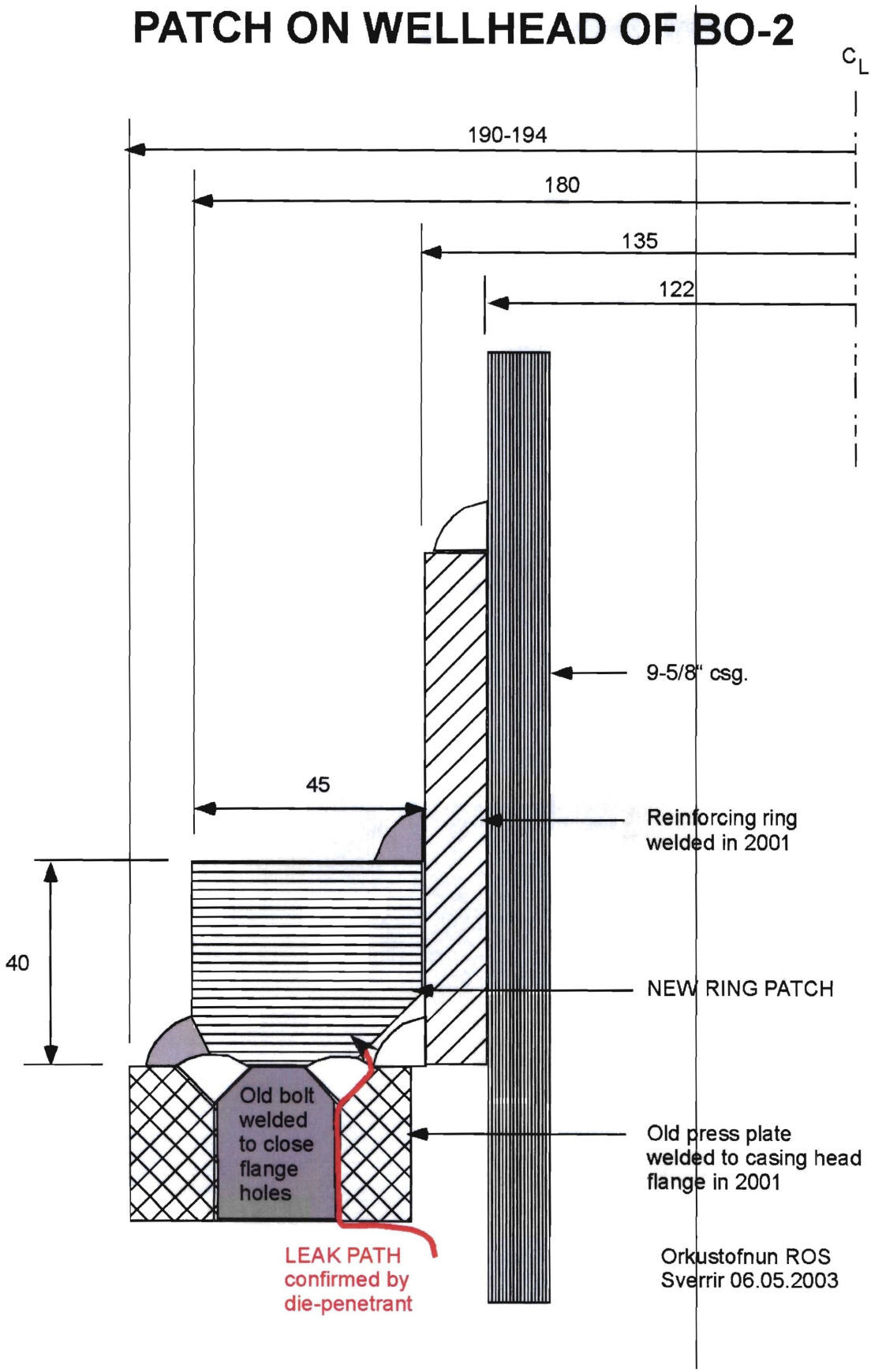

Figure 7. Drawing shows where the leak was – a pinhole defect of a weld. The drawing also shows the design of the ring-patch to cover the leak. The patch was welded in place May 6th.

Figure 8. Patch welded in place by a COTUMER welder.

Figure 9. Expansion spool being repacked by Bernard. Injection tool is connected to the spool and he is holding the "rat shit".

Figure 10. Leak on pressure release tap and between flanges on the expansion spool of BO-2.

Figure 11. Bolts being tightened on the expansion spool of BO-2 (lower flange) where there was a leak (see Fig. 10).

Figure 12. Two bolts were rusted away on the lowest wing valve. Valve since 1970.

Figure 13. Close-up of bolts missing from flange on 13-3/8" casing head.

Figure 14. Reinforcing rods 20x20 mm welded over the flange pair of the 3-3/8" wing vale to make up for the loss of the two corroded bolts and suspected weakness of the other stud bolts.

Figure 15. From under the scale deposits on the expansion spool a crack showed up on the flange just below the pressure release port. If it propagates deep it could result in leak.

Figure 16. Discussions on what to do….