FIELD EXPERIENCE WITH COMPACT PROVERS

by

W GRANT

PHILLIPS PETROLEUM COMPANY

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FIELD EXPERIENCE WITH COMPACT PROVERS - PART I

B.G. Grant

PHILLIPS PETROLEUM COMPANY NORWAY

INTRODUCTION

The offshore oil industry has been continually faced with new challenges. Early in the history of the Ekofisk project, Phillips Petroleum Norway, as operator, had the problem of recalibration of liquid meter provers on nine platforms. An analysis of the various means of accomplishing the recalibration was studied and the following four general methods were evaluated:

1. The conventional water draw method
2. Master meter method utilizing the operating fluid
3. A conventional ball type pipe prover in conjunction with a transfer meter
4. A compact (ballistic) meter prover

Each of the first three methods had negative factors which were not easy to overcome on an offshore platform using crude oil with a very high vapor pressure. The fourth method had not been tried and proven offshore but it had the advantages of small size, weight and speed which was ideal for Phillips Norway's application. Our cost analysis showed that the compact prover could be adapted to our application for about the same cost as the other three conventional methods. An additional factor in favor of the compact prover recalibration system is that there would be less risk of lost production due to the time the platform prover must be out of service.

After consideration of the advantages and disadvantages of the compact prover, Phillips entered into a development contract to test and demonstrate the feasibility of this type system. We had to assure ourselves that there was no accuracy problem, then demonstrate the compact prover system to the Norwegian Authorities. The compact prover manufactured by Flow-Technology was selected and the Norwegian Authorities required that the unit must correlate with a conventional pipe prover to within ± 0.03 percent with repeatability of ± 0.02%. BROOKS

The dimensions of the compact prover system were limited by the narrowest passageway available to move it from a lay down area to the platform prover skid on the platform with the most congestion. Due to a right angle turn through a doorway on two of the platforms the length was also limited. The weight of the unit was restricted so it could be lifted on board by any platform crane in weather up to the maximum swells allowed using the whip.

DEMONSTRATION

In August, 1980, a series of tests were performed in Tulsa, Oklahoma, with the compact prover system operating in conjunction with a conventional ball type pipe prover. The following procedures were carried out:

1. The certificates of calibration of the instruments were inspected.

2. All thermometers were recalibrated using a cold bath and a certified etched stem thermometer.

3. A leak detection test was performed on the compact prover seals and was verified by releasing 100 cc of fluid.

4. Calibration runs were made with one series at a faster flow rate (190 GPM) followed by a series at a slower flow rate (157 GPM).

5. A series of tests were performed to demonstrate the change, or lack of change, in the compact prover performance when the actuator piston pressure was varied between 30 and 45 pounds per square inch gauge.

The comparisons of the regular prover calibration with the compact prover were much better than our expectations. The compact prover was within 0.01% of the water draw base volume of the conventional prover using the faster flow rate and was 0.002% using the slower flow rate. The conventional prover was an 8 inch bi-directional ball type and the compact was 12 inch, 10 gallon model. Figure 1 is a schematic diagram of the demonstration test configuration.

The test results as shown in Figure 2, assured the Norwegian Authorities and Phillips that the compact prover provided the necessary accuracy for the recalibration of our offshore meter provers. Only the question of how often to perform a water draw calibration of the compact prover remained unanswered. It was agreed that a water draw would be made at Phillips Petroleum Company Norway, Shore Base, before the equipment was sent offshore by work boat. Diesel oil from the regular platform fuel system was to be the recalibration fluid. Phillips had earlier obtained a 10 gallon Seraphin can which was certified by the U.S. National Bureau Of Standards and recertified by Det Norske Justervesen upon it's arrival in Norway, Valving arrangements were installed on the compact prover so that a water draw calibration could be performed in only a few minutes. With this convenient arrangement, the waterdraw calibration was repeated many times during a day of testing. All the results were less than the uncertainty of the Seraphin can.

1980 RECALIBRATIONS

The calibration crew required one week to complete the first platform recalibration. Of course, the first two days of this time were spent waiting on the weather before the compact prover could be hoisted onto the platform from the work boat, which is one of the risks we have in all our offshore operations. The first set of recalibrations on this platform showed a drift in the platform prover of 0.09% from the original factory water draw. We were disappointed to see this much drift so the ball was resized to 5% overfill and new calibrations were run. The drift was 0.056% but was in the opposite direction which did not boost our confidence. The drift of the next three platform provers was in the same direction, which suggested that there might be a bias in the system. We were satisfied when the fifth platform prover showed a drift in the other direction. The results from these recalibrations are shown in Figure 3. We considered offshore recalibration of the provers to be slightly less accurate than the factory calibration so only the one prover with a shift greater than 0.05% had the base volume changed in the computer. A water draw calibration of the compact prover was carried out periodically while it was being used offshore. Figure 4 shows the results of the onshore water draw and five additional water draws while offshore. The compact prover was relatively easy to flush out the diesel with fresh water, in order to perform the water draw calibrations.

The Norwegian Authorities were satisfied with the results of this series of recalibrations and they agreed that the next recalibration in two years, would include only the provers connected with the metering to the oil pipeline.

All the offshore provers would be recalibrated again in 1984.

1983 RECALIBRATIONS

The compact prover used for the 1980 recalibrations utilized micro-switch detectors. The compact prover selected for the next recalibration of the provers was a new model equipped with optical switches for even greater accuracy and has a 15 gallon capacity. A series of correlations were made at Bromborough, England, to establish the compact prover water draw volume with the same 10 gallon Seraphin can used during the 1980 recalibrations.

The compact prover unit was moved to the Seal Sands Teesside Plant for a demonstration and trial run of the equipment. Previous recalibrations of the inlet prover at this plant had utilized a conventional ball-type prover with a standard transfer meter.

We wanted to see what difference, if any, the use of the normal crude oil and the diesel oil system used with the compact prover might have on the results. The demonstration with the compact prover utilizing diesel compares with regular recalibrations as follows:

1. Ten months earlier -0.009%

2. Two months later +0.004%

3. Fourteen months later -0.003%

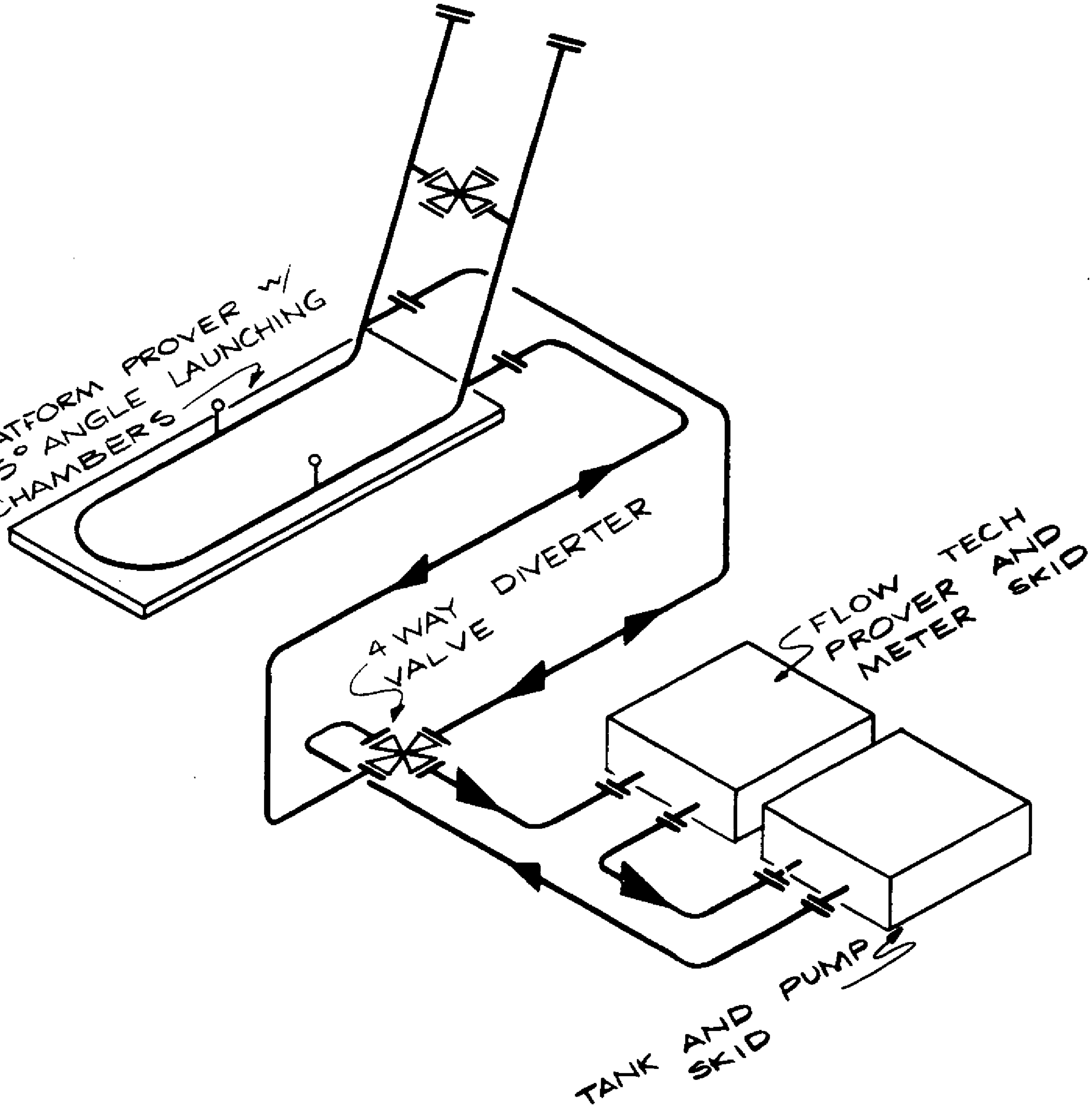
The regular recalibrations utilized the crude oil passing through the station.

The 15 gallon compact prover was used to recalibrate a 16 inch bi-directional prover on the Amoco 2/4G receiving platform and the 30 inch bi-directional prover on the 2/4T platform, both at Ekofisk Center and a 16 inch bi-directional prover on Albuskjell 2/4F platform. The results of these recalibrations are shown in Figure 5. A water-draw calibration of the compact was made before and after each of these recalibrations and the results are shown in Figure 6.

CONCLUSIONS

Phillips experience has proven the compact prover to be a very convenient method to perform the recalibration of offshore platform provers. Frequent water draw calibration of the compact prover gives added assurence that the certification of the offshore platform provers is as correct as possible. Our confidence in the compact prover has been assured and we are of the opinion that the recalibration of our offshore provers are as precise as the original factory calibrations.

The author wishes to thank T.L. Hillburn, Phillips Corporate Engineering, for permission to use excerpts from his internal report on the 1980 recalibrations.



DEMONSTRATION TEST CONFIGURATION

TULSA OK., AUGUST 1980

FIGURE 1

RESULTS OF DEMONSTRATION TESTS
TULSA, OKLAHOMA

Compact Prover	Pipe Prover	Master Meter
Base Volume 9.9240 Gal.	Base Volume 168.611 Gal	Size 2 inch
Flow Tech SN BFP-004	Signet SN 107/SFC 8413	Daniel CR SN 77-T-477

	Pass	MASTER METER K Gross Before	After		Pipe Prover Volume
Slower Rate	1	116.690	116.705	Using K=116.702	168.628
	2	116.701	116.698		168.644
	3	116.707	116.712		168.592
	4	116.703	116.697		168.608
	5	116.707	116.685		168.600
	Average	116.702	116.698		168.614
				Correlation	0.0018 %
Faster Rate	1	116.528	116.514	Using K=116.517	168.593
	2	116.516	116.499		168.627
	3	116.504	116.533		168.643
	4	116.511	116.512		168.617
	5	116.526	116.523		168.650
	Average	116.517	116.516		168.626
				Correlation	0.0089 %

33 passes were run while varying the actuator pressure from 27 psig to 45 psig. The pulse count was 1158 for 26 passes and varied one count on the balance.

Figure 2.

RE-CALIBRATION OF NINE BALL-TYPE PROVERS - 1980

Prover Size and Location	Original Calibration (U.S. BBL.)	Re-calibration (U.S. BBL.)	Percent Drift
30"/Ekofisk Center FTP	120.4699	120.4660	-0.003
30"/Ekofisk Center Tank	109.2977	109.2920	-0.005
18"/Tor 2/4E	42.3148	42.3118	-0.007
16"/Edda 2/7C	43.1290	43.1278	-0.003
16"/N. Eldfisk 2/7B	43.2425	43.2240	-0.043
16"/S. Eldfisk 2/7FTP	42.6939	42.6979	+0.010
16"/Albuskjell 2/4F	38.4219	38.4097	-0.032
16"/Albuskjell 1/6A	38.0480	38.0268	-0.056
10"/Cod 7/11A	10.1424	10.1433	+0.009

Figure 3.

WATER DRAW CALIBRATION OF COMPACT PROVER (2309.63 IN ^{3} capacity)

Site	Pass	Net Volume ($In.^3$)	Correlation (Percent)
Tananger Base	1	2283.903	
	2	2284.078	
	3	2284.078	0.009
	4	2284.056	
	5	2283.873	
Albuskjell Alpha	1	2284.318	
	2	2284.227	
	3	2284.182	0.006
	4	2284.175	
	5	2284.189	
EDDA	1	2284.141	
	2	2284.239	
	3	2284.226	0.011
	4	2284.111	
	5	2284.363	
Eldfisk FTP	1	2284.408	
	2	2284.339	
	3	2284.403	0.005
	4	2284.421	
	5	2284.317	
Ekofisk (I)	1	2284.111	
	2	2284.159	
	3	2284.063	0.005
	4	2284.063	
	5	2284.182	
Ekofisk (II)	1	2284.275	
	2	2284.275	
	3	2284.427	0.009
	4	2284.313	
	5	2284.211	

Figure 4.

RECALIBRATION OF BALL - TYPE PROVERS - 1983

Prover Size and Location	Original calibration (U.S. BBL.)	1980 Recalibration (U.S. BBL.)	1980 Percent from original	1983 Recalibration (U.S. BBL.)	1983 Percent from Original	1983 Pecent from 1980
30" Tank	109.2977	109.2920	-0.005	109.2971	-0.001	+0.005
16" 2/4G						
Vol A	42.26089	New	---	42.2528	-0.021	---
Vol B	42.26855	New	---	42.2598	-0.021	---
16" Alb. 2/4F	38.4219	38.4097	-0.032	38.4096	-0.032	Nil

Figure 5.

1983

WATER DRAW CALIBRATION OF COMPACT PROVER (3472.16 in^3 capacity)

Site	Pass	Average Volume Per Pour (in^3)	Correlation Percent
Before 2/4T	1 2 3	3471.9180 3472.1142 3471.9527	0.007
After 2/4T	1 2 3	3471.8490 3471.8337 3471.8990	0.002
Before 2/4G	1 2 3	3471.1692 3471.3386 3471.5241	0.010
After 2/4G	1 2 3	3471.9038 3471.8764 3471.9916	0.003
Before 2/4F	1 2 3	3472.2574 3472.3304 3472.3805	0.005
After 2/4F	1 2 3	3471.9532 3471.9838 3471.9685	0.006

Figure 6.

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.