ESP's: ON AND OFFSHORE PROBLEMS AND SOLUTIONS

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ABSTRACT
This is the fifth in a series of papers, which deal with literature on Electric Submersible Pump (ESP) application problems and solutions. All the papers summarize and categorize ESP reference literature by a number of different topics. The objective is to list briefly problems mentioned in various papers and the solutions to those problems, which are detailed in the given references. Originally, there was also an attempt to relate problems to various field conditions, but that effort was dropped because of a general lack of enough application data to accomplish this. Nevertheless, it is hoped that this paper and the previous versions will provide a good reference set for anyone wanting to improve on the performance and success of their ESP applications. All of the previous papers are referenced below.

INTRODUCTION
This paper contains referenced categories of problems that have been encountered in field operations and the solutions that have been found and published in the literature since **1998.** It adds another **81** references to the prior database of 203 references. The discussion for each problem/solution set is brief, but serves as an index to the particular reference, where more details can be found. Papers on field cases are discussed as well as articles that are tutorial in nature. Many developed studies such as design techniques and recommended procedures are also covered. Also, some field operational papers were not included if they presented identical information. This study was originally intended to be a review of the field cases and a summary of various failures and their causes as a function of the conditions present. The well and field conditions still remain as an exception for a given paper to list. Only a few contained sufficient field condition data, which would have allowed problems and solutions to be correlated to conditions.

The number of entries is some indication of where the interest is in many of the literature presentations. The following list of subjects has the number of entries listed beside the topic:

Components:
Pumps **(1)**
Motors (2)
Cable (3)
Monitoring **(8)**

Optimization:
Design **(5)**
Optimize operations (2)
Run lives **(10)**
Misc-overall (2)

ESP Application:
Harsh conditions **(11)**
Gas **(3)**
Heavy oil (3)
Coil Tubing ***(5)***
Downhole oil/water separation **(4)**
Subsea (9)
Unique configurations (7)

Alternative Lift studies:
ESPCP **(4)**
Misc (3)

The above listing shows monitoring, problems with harsh conditions, subsea applications, unique completion configurations, use of coil tubing, and ESP run life to be of strong interest. Also, the applications in harsh conditions, gas, and heavy oil are continuing obstacles to long run lives and proper design. In the first 'Problem & Solution' paper, the heavy categories included the ESP components (pump, seal, motor, and cable), electrical problems, harsh conditions, and runlife. This was the evaluation from only **50** papers. This paper evaluates **81** papers. Over this ten plus year span, it is interesting to note that harsh conditions and run life are still common categories, but problems identified with downhole components have decreased and special or unique equipment completions and deployment methods have taken their place.

PREVIOUS PROBLEM & SOLUTION PAPERS:

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"Operational Problems and Their Solutions – Electric Submersible Pumps", Lea, J.F. and Bearden, J.L., SPE Gulfcoast ESP Workshop, Houston, Texas, April **1992.** (**10** references).

"Electrical Submersible Pumps: On and Offshore Problems and Solutions", Lea, J., Wells, M., Bearden, J., Wilson, L., Shepler, R., Lannom, R., SPE Paper **28694,** April **1994.** (**45** references)

''ESP's: On and Offshore Problems and Solutions", Lea, J.F. and Bearden, J.L., SPE Paper **52159,** March **1999.** (**98** references)

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6. "Low Kilowatt Submersible Cable Lowers Electrification Costs for South China Sea Offshore Platform", W. van Zanten, OTC Paper **#13230,** Apr. **30,2001.**

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10. "Installation of Fiber Optic Monitoring Systems in ESP Wells", P. Newberry, Sixth European ESP Roundtable, Aberdeen, Scotland, Feb **15,2000.**

11. "Application of ESP Downhole Monitoring Data to Captain Field Management", J. Clark, Sixth European ESP Roundtable, Aberdeen, Scotland, Feb **15,2000.**

12. "Demystifying ESPs: A technique to make your ESP talk to you", A. Williams, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr **26,2000.**

13. “Utilizing Electric Submersible Pumping Systems to Acquire Valuable Well Test Data”, S. Degen, et al, Canadian International Petroleum Conference, June 4,2000.

14. “Comparative Performance of Downhole Pressure Monitoring Systems In the Guaduas Field (Colombia): Wireline Retrievable Quartz Memory Gauges”, T. Habliston, et.al., SPE Gulf Coast ESP Workshop, Apr 25,2001.

15. “Electrical Submersible Pumping Systems for Applications in Sour Environment”, A. Limanowka, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 25, 1999.

16. “Consideration for ESP Usage in CO_2 Floods”, F. Collier, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28, 1999.

17. “Asphaltene Deposition Problems in Oil Industry with Focus on ESP Applications”, W. Limanowka, et al, SPE Paper 56662, Oct 3, 1999.

18. “An Encapsulated System Design for Severe CO_2 Corrosive Environment in Exxon – Mobil’s Postle Field”, Y. Bangash, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 26,2000.

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22. “ESP’s Application in Oritupuno-Leonablock, East Venezuela”, G. Novillo, et al, SPE Paper 53966, Mar 25, 1999.

23. “ESP Failure Reductions in a field with CO_2 Flood”, M. McNeely, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 25,2001.

24. “Scale Control in Submersible Units in EI Trapial Field”, G Henderson, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 25,2001.

25. “Desander Protects Downhole Pump”, M. Briffett, Oil & Gas Journal, Nov 5,2001.

26. “Tapered Pump Experimental Tests with Light and Heavy Oil in PDVSA Intevep Field Laboratory”, R. Pessoa, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28, 1999.

27. “ESP Gas Separator Performance Evaluation and Application Guideline”, W. Lee, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28, 1999.

28. “Gas-Liquid Flow Through Electrical Submersible Pumps”, R. Cirilo, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28, 1999.

29. “Advances in Heavy Oil Lifting in the Morichal Area of Venezuela”, J. Blann, et al, SPE Paper 52211, Mar 28, 1999.

30. “Optimizing Heavy Crudes Production – A Downhole Fluid Conditioning Approach”, P. McCurdy, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 26,2000.

31. “South China Sea Gas Lifted Oil Well Conversion Utilizing Coil Tubing Electric Submersible Pumping Systems”, R. Shepler, et al, SPE Gulf Coast ESP workshop, Houston, Texas, Apr 28, 1999.

32. “Cable Internal Coiled Tubing Deployed Submersible Pump Installation”, J. Patterson, et al, SPE Gulf Coast ESP workshop, Houston, Texas, Apr 26,2000.

33. "Chevron's Experience with Coiled Tubing Deployed ESP's, Banzala Field, Offshore Angola", R. Storey, et al, SPE Gulf Coast ESP workshop, Houston, Texas, Apr 26,2000.

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35. "Sub-Surface Safety Systems for CT Deployed ESP's", M^ck. Webster, et al, SPE Gulf Coast ESP workshop, Houston, Texas, Apr 25,1999.

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41. "World's Longest Sub-Sea Tie Back of an Electrical Submersible Pump", S. Harrall, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28,1999.

42. "Subsea Artificial Lift – the Advantages of Subsea Boosting", J. Svaeren, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28,1999.

43. "Dual ESP Systems – Case Histories from Offshore Nova Scotia", S. Dyer, et al, Sixth European ESP Roundtable, Aberdeen, Scotland, Feb 15,2000.

44. "Sub Sea ESP's, - Y2K Update", D. Leslie, Sixth European ESP Roundtable, Aberdeen, Scotland, Feb 15,2000.

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50. "ESP-Gas Lift Combination – A Successful Trial for the First Time in ONGC, India", K. Kahali, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28, 1999.

51. "Production Optimization by Combined Artificial Lift Systems and its Application in Two Colombian Fields", H. Borja, et al, SPE Paper 53966, Apr 21, 1999.

52. "The Analysis and Prediction of ESP Failures in the Mine Point Field, Alaska", S. Sawaryn, et al, SPE Paper 56663, Oct 3, 1999.

53. "Combined ESP / Auto Gas Lift Completion Design – Stag Field", J. Holmes, et al, Sixth European ESP Roundtable, Aberdeen, Scotland, Feb 15,2000.

54. "Combined ESP / Auto Gas Lift Completions in High GOR/High Sand Wells on the Australia Northwest Shelf', K. Aitken, et al, SPE Paper 64466, Oct 16,2000.

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63. "MPU ESP Troubleshooting Method", J. Ketchum, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28, 1999.

64. "Performance of ESP's Operating in ONGC, India Analyzed", T. Ramachandran, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28,1999.

65. "Root Cause Failure Analysis of Electric Submersible Pumping Systems", A. W. Limanowka, et al, SPE Gulf Coast ESP Workshop, Houston, Texas, Apr 28,2000.

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[illegible]	[illegible]	[illegible]	[illegible]	Problem	Solution
1	N/A	99	N/A	Erosion and abrasive wear due to pumping solids that can lead to radial instability, downthrust, erosion/corrosion, vibration	Upgraded journal bearings by considering mounting design, bearing material and bearing spacing. Application case histories are presented.

Table 2: Motors					
Ref	#ESP	Yr	Location	Problem	Solution
2	1	00	Canada	Motor cooling	A motor cooling by-pass system was used and it helped to increase the economic lib of Gas wells.
3	111	01	China	Application of ESP motor in low volume deviated well.	Field case of ESP in [redacted] suggested that the velocity of fluid on motor housing should be less than 0.04 m/s.

Table 3: Cable					
Ref	#ESP	Yr	Location	Problem	Solution
4	N/A	99	N/A	Cable problems: High temperature, CO2 floods, high GOR, aromatic hydrocarbons	Understanding benefits and limitations of cable components to *optimize performance* while minimizing costs by intelligent selection.
5	N/A	00	N/A	ESP cable design and application.	Tutorial & Guidelines.
6	N/A	01	S. China Sea	Provide effective cost delivery of electrical power via sub-sea cable to small, isolated, & unmanned platforms.	Solar & thermal generators are limited in KW and have high operating costs for this application. Choice was a modified ESP power cable

Table 4: Monitoring					
Ref	#ESP	Yr	Location	Problem	Solution
7	N/A	98	Alaska	Production management of ESP systems	Using a commercial expert system *software* package to demonstrate the capability of managing wells equipped with ESP's
8	370	99	)	Experience wit premium do [illegible]	Troubleshooting and remedies of ESP. Field case studies are presented
9	N/A	00	N/A	Permanent [illegible]le ESP monitoring [illegible]tems	Presents the applications and case studies where the instrumentation of this monitoring system has been employed.
10	1	00	[illegible].K., W[illegible] Farms.	ESP monitoring systems	Described the installation of Fiber optic monitoring systems in ESP wells.
11	N/A	00	Captain Field. U.K.	Installation of ESP DHM system in the Captain Field	The system was reliable & significantly contributed to the overall management of the filed.
12	N/A	00	N/A	Performance monitoring of ESP wells	Discusses gradient traverse plot analysis technique for analyzing and predicting ESP performance.
13	11	00	Alberta, Canada	Acquiring quality well test data.	Describes the utilizing of ESP to acquire data at a relatively inexpensive cost.
14	4	01	Colombia	Comparison tests on quartz memory and permanent gauges in 4 producing wells.	Accuracy & reliability is related to cost. Lower level gauges can provide cost effective, real-time data for operational control.

The use of sophisticated monitoring equipment and techniques is expanding, especially for high cost intervention wells. These systems not only sense and communicate downhole data; they can also be configured to monitor equipment and well performance (Fig. 1). This is the initial step in establishing a smart or intelligent control system (Fig. 2).

Table 3: Harsh Conditions (Sand, Scale, Corrosions)

Ref	#ESP	Yr	Location	Problem	Solution
15	N/A	99	Canada	Development of ESP equipment for use in harsh environment, especially with high H_2S concentration.	Discusses equipment with modified metallurgies and its application.
16	N/A	99	N/A	The use of ESP in CO_2	Several case histories are presented. Problems & solutions are provided on issues such as corrosion, gas handling, asphaltenes & WAG.
17	N/A	99	Alberta, Canada	Asphaltene deposition	Presents ideas and methodologies on how to predict, diagnose, prevent and treat asphaltene deposition problems
18	2	00	Oklahoma	CO_2 corrosion	Installation of Encapsulated system.
19	121	00	Alaska	Asphaltene deposition stuck pumps by sand & scale, scale deposition & sand problems.	Developing several well operation procedures for treating under-performing ESP installations.
20	N/A	00	Alaska	Scale problems	Scale inhibition program helped to decrease number of ESP failures.
21	4	00	Alaska	Sand & scale problems.	Developed improved techniques.
22	60	01	Venezuela	Sand, scale and corrosion problems	Developed improved design techniques
23	102	01	Texas	Reduce total cost of CO_2 operations.	Using the RCFA program to determine cause of ESP failures on keeping on the total cost of operations was very successful.
24	N/A	01	Argentina	Calcium carbonate scale	Using water analysis techniques for prediction of scale and corrosion. Using cable with capillary tubes in combination with scale inhibitors proved to be efficient and successful.
25	30	01	Canada	ESP pump failures due to production of formation sand causing higher operating costs.	12 Downhole desanders installed over 2-year period. Pump with 203-day run, compared to failed pumps with 126-day avg. showed good condition and performance.

Harsh environment applications continue to be prevalent problem areas. ESP systems continue to be pushed into more difficult applications, which require new technical solutions. These problems include corrosion from CO_2 and H_2S exposure, plugging from scale and asphaltenes, and equipment wear due to production of wellbore solids. Paper 22 discusses problems encountered with an annular water based treatment squeeze for scale. The process resulted in formation damage or blockage and a reduction in fluid production (Fig. 3). Testing of several inhibition processes found a non-damaging procedure.

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Ref	#ESP	Yr	Location	Problem	Solution
26	N/A	99	N/A	Pumping gassy fluid	Lab. Testing and experimental results on one manufacturer's rotary type separators (past and new technology)
27	N/A	99	Venezuela	Handling of free gas	Development of a tapered configuration at the pump intake with special gas handling stages without ESP performance degradation with both light and heavy oils. 42 - 50% free gas by volume. Total dynamic head performance improved 10% respect to liquid curves.
28	N/A	99	N/A	Pumping gassy fluid	Lab tests and experimental results on three different submersible centrifugal pumps

Table 7: HEAVY OIL					
Ref	#ESP	Yr	Location	Problem	Solution
29	3	99	Venezuela	Production of 8.5 – 12.5 API crudes (60-180 cp @ 117 - 148 F) and 10–13 API crudes (766 cp @ 138 F)	ESP's proved successful as lift means (high production, low cost, ctc). Injecting a diesel diluent below the pump resulted in reducing wellhead pressure, viscosity and surface friction.
27	1	99	Venezuela	Production of 11.6 API crudes (15221.3 cp @ 66 F)	Using special pump stages from ESP manufacturers. GCNPSH from Centrilift used a tapered configuration at the pump intake.
30	4	00	N/A	Optimizing heavy crudes production (API< 14, viscosity >10000 cp)	Development of a Rheologically enhanced production system and lab. Tests for production optimization in wells producing heavy hydrocarbons. Equipment sizing can be done n more efficient manner.

Table 8: Coiled Tubing Deployment					
Ref.	#ESP	Yr	Location	Problem	Solution
31	N/A	99	Brunei	Offshore workover costs.	Describes the successful conversion of gas lift to a high flow ESP.
		00	Alaska	Alternate ESP deployment system	Describes the installation & start-up of the first CT deployed ESP'S w/power cable inside the CT.
		00	Angola	Alternate ESP deployment system	Describes the installation of the first CT deployed ESP system.
34	8	00	Qatar	Alternate ESP deployment system	Discusses CT deployed systems versus conventional equipment workover efficiency improvements, review of downtime problems and their remedies.
35	N/A	01	N/A	Subsurface safety systems for CT deployed ESP's.	Describes the new safety systems & their main characteristics in details.

Coiled tubing deployed ESP systems continue to be field-tested and evaluated. They are one solution for the future growth of subsea, remote well site, and live well deployment applications (Fig. 4).

Table 9: Downhole Oil/Water Separation					
Ref	#ESP	Yr	Location	Problem	Solution
36	1	99	N/A	Sand producing reservoirs in the range of 0.1 – 1% by volume	Development of PCP-DHOWS (progressive cavity pump downhole oil/water separation and ESP-DHOWS. It prevents plugging of the injection zone, increases system run-life and increase oil production in a well through increased drawdown
37	3	00	France	Minimize effects of excess water production.	Application, discussion of cyclonic downhole oil/water separation presented.
38	N/A	00	Various	Minimize effects of excess water production.	Discussion on the health, safety and environment issues associated with DOWS.
39	N/A	01	N/A	Confidence in downhole oil-water separation systems down to sparse economic success.	Separation modeling software allows realistic prediction of well performance.

Table 10. Subsea

Ref	#ESP	Yr	Location	Problem	Solution
40	1	99	Brazil	Deepwater installation of a subsea ESP	Report update on the first year run for the first deepwater installation of a subsea ESP
41	N/A	99	North Sea	Marginal reservoir development	Discussion on technical issues related to the operation of ESP equipment and providing some recommendation for their development.
42	N/A	99	Various	Subsea Roosting	Provided the results of development programs carried out by Framo Eng. AS during the last 15 years.
43	9	00	Canada	Dual ESP installation.	Provided detailed explanation about the technology of Dual ESP.
44	N/A	00	Various	Subsea ESP's technology	Field cases update.
					Using a "Prepacked system" to move costs.
46	40	00	China	Difficulties in restarting of ESP after shutdown due to heavy oil, power supply system failure. low air temperature and cold seawater pose. Limited platform space.	Using an efficient OVDMT, ESP can softly start with VSD and reducing space areas taking ESP surface equipment. ESP run life increased from 360 to 460 days.
47	118	01	Indonesia	Restarting stuck ESP's and prevent costly workovers.	Full explanation of the "Jog" program that can break the unit free and bring the motor up to full speed.
48	1	01	N.Sea	Marginal reservoir development.	Discussion of solutions for the technical challenges encountered on Shell's Gannet E.

This area shows a growth in the number of papers related to subsea deployments. The North Sea Gannet Field extended reach subsea wellbore completion and subsea electrical transmission is discussed in paper 41 (Fig. 5). Deployment of dual ESP systems (Fig. 6) is discussed in paper 43. Deployment of a primary and backup ESP system will decrease the intervention costs by extending the run life of the total system and help in the justification of ESP's in subsea applications.

Table 11: Unique Configurations

Ref	#ESP	Yr	Location	Problem	Solution
49	N/A	99	N/A	Well [illegible] fluid paths.	Evaluate the [illegible] f ESP system by using two simulators: SubPump & PERFORM softwares.
S0	2	99	India	Low gas injection pressure, requirement of large number of stages (440 stages)	ESP – Gas lift combination. Increased production rate
51	4	99	Colombia	Restricting conditions: operating depth, water cut. pumping gassy fluid, et	ESP – Gas lift combination. Maximized production and minimize cost. Advantages are outlined.
52	318	99	Alaska	Predict the probable number of failures and identify which ESP's are the most likely to fail	Using the Weibull distribution and the Bathtub reliability model. Use Monte-Carlo techniques to stimulate the failure rates.
53	6	00	N/A	High gas fraction, continuous slugs with a short frequency, large volumes of sand, rapid onset of water production and rapid reservoir pressure depletion	Development of the combined ESP / Auto gas lift completion design
54	7	00	Australia	High GOR / High sand wells	Development of the combined ESP /–Auto gas lift completion design. Improved abrasion resistance by using silicon carbide bearings and bushings. Increased production rate 40 - 80% and improved ESP runlife by more than 100%
55	7	01	Sumatra, Indonesia.	Installation the "Advanced Gas Handler" in Conjunction with ESP's.	The Advanced Gas Handlers have been successful in improving the pumping efficiency and in increasing the run times of ESP installations in the Atti field.

Several papers in this grouping deal with the installation of two artificial lift means, ESP and gas lift, to overcome the problems of equipment runlife and size. Gas lift can be incorporated with an ESP deployment for two main purposes. First, it can be a backup lift system. Second it can be utilized as a dual lift system, which reduces the equipment requirements imposed on individual ESP or gas lift systems. Figure 7 shows a pressure traverse of the produced fluid as it moves to the ESP intake, thru the pump, up the tubing to the first gas lift mandrel, and on to the surface.

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Ref	#ESP	Yr	Location	Problem	Solution
56	N/A	00	N/A	Viscosity correction of centrifugal pump performance curves	Development of a computerized model used to correct the performance curves for higher viscosities
57	N/A	00	N/A	ESP design with limited data	Some examples of design and analysis concepts are presented for ESP installations.
58	N/A	00	N/A	Mixed flow design ESP's.	Describes new mixed flow stage pumping system for flows and specific speeds much lower than the existing mixed flow design ESP's.
59	N/A	00	N/A	Design and application of Inverted pump systems.	Discuss the specific equipment used in inverted systems, it's function, and why it is required.
60	4	00	Gabon, Africa	Application design.	Discuss the application of the High Resistance Grounding technology to Tchatamba wells.

Table 15: Optimize Operations					
Ref	#ESP	Yr	Location	Problem	Solution
61	N/A	00	N/A	Improving reservoir management and workover results n shallow, multi-layered reservoirs	Development of Test Guided Workover (TGW) tool. It guides well workover, remediation programs, and proper sizing of the next artificial lift systems
62	35	00	N/A	Operational problems: emulsion formation, gas locked, underloading and overloading conditions	Optimize an ESP wells by utilizing a closed – loop control techniques. It manages operational problems, optimizes well oil production. maximizes continuous operation of the equipment and optimizes energy consumption

[illegible]

Ref	#ESP	Yr	Location	Problem	Solution
63	121	99	Alaska	Determine system failure analysis	Using MPU ESP troubleshooting method. determine root cause of decline
64			India	Failure analysis and improving run life	ESP performance analysis, setting up an ESP repair and test facility, improved data base management
65				Determine RCFA of ESP systems.	Provided modifications to RCFA methods, specific to ESP applications. Explained the difference between failure mode and cause of failure.
66	N/A	00	N/A	Is there a shift in the ESP run life paradigm?	Demonstrate the benefits of imoroved run life measurement where a substitution/replacement policy for individual ESP components is practiced.
67	N/A	00	Alaska	Illustrating the growth, renewal & decline of single ESP populations and their transition to Dual ESP system	Critical assumptions were justified using published data and the commercial implications of the conclusions are presented.
68	N/A	01	Oklahoma	How to predict the unit runtime for a population of ESP's	Development of a runlife simulator. Different field cases are presented
69	N/A	01	N/A	Tracking and analyzing ESP failures	Describes guidelines to achieve consistency in data collection. i.e. general data set of quantitative parameters and a standard nomenclature for coding ESP failure information
70	N/A	01	N/A	Run life performance	Develop a performance benchmarking of ESP installations to evaluate ESP performance
71	7	01	N/A	Prolong runlife of vibration	A complete analysis and description of problems and solutions presented from field examples.
72	N/A	93	N/A	Discusses problems of installing ESP's thru doglegs into horizontal sections.	Modifications to equipment have allowed successful runs in high bend doglegs.

More emphasis is being placed on improving runlife, by the collection of data and its analysis. Constant monitoring and evaluation of this performance data will lead to extended run times. Typical data plots are shown in figures 8 & 9.

Table 15: Miscellaneous - Overall

Ref	#ESP	Yr	Location	Problem	Solution
73	N/A	00	N/A	List new developments.	Describes the development and testing for a new brushless DC type of motor for ESP downhole applications.
74	N/A	01	N/A	Design and build-in gauges to motors to reduce the costs and effort of gauge deployment.	New and needed development for ESP gauges.

Table 16: ESPCP					
Ref	[illegible]	[illegible]	[illegible]	Problem	[illegible] Solution
75	1	99	Wyoming	Installation of ESPCP in a well that had a casing leak.	ESPCP have extended the run life of the well.
76	I	99	Oklahoma	Install ESPCP in the same well that was previously produced with beam pump.	Presented the advantages of ESPCP over the beam pump.
77	N/A	00	N/A	Describe the components of ESPCP.	Tutorial.
78	2	00	Alaska	Generating desired torque for hard starting ESPCP	Field tests on ESPCP.

Table 17: Lift Alternatives					
Ref	#ESP	Yr	Location	Problem	Solution
79	N/A	99	Alberta, Canada	What is the appropriate rodless PC lift system fora highly deviated wellbore?	Discussion of merits of various methods of lift.
80	N/A	00	N/A	Medium and heavy viscous oil horizontal wells to mitigate problems with sandy high volume production	Development of Permanent Magnet Synchronous Motor - Progressive Cavity Pump (PMSM-PCP). Comparison of lift systems before and after PMSM-PCP system are provided with field results.
81	N/A	01	N. Sea	Producing wells with high GOR flows.	Field trial of a hydraulic driven submersible pump. Handled GVF's to 75%

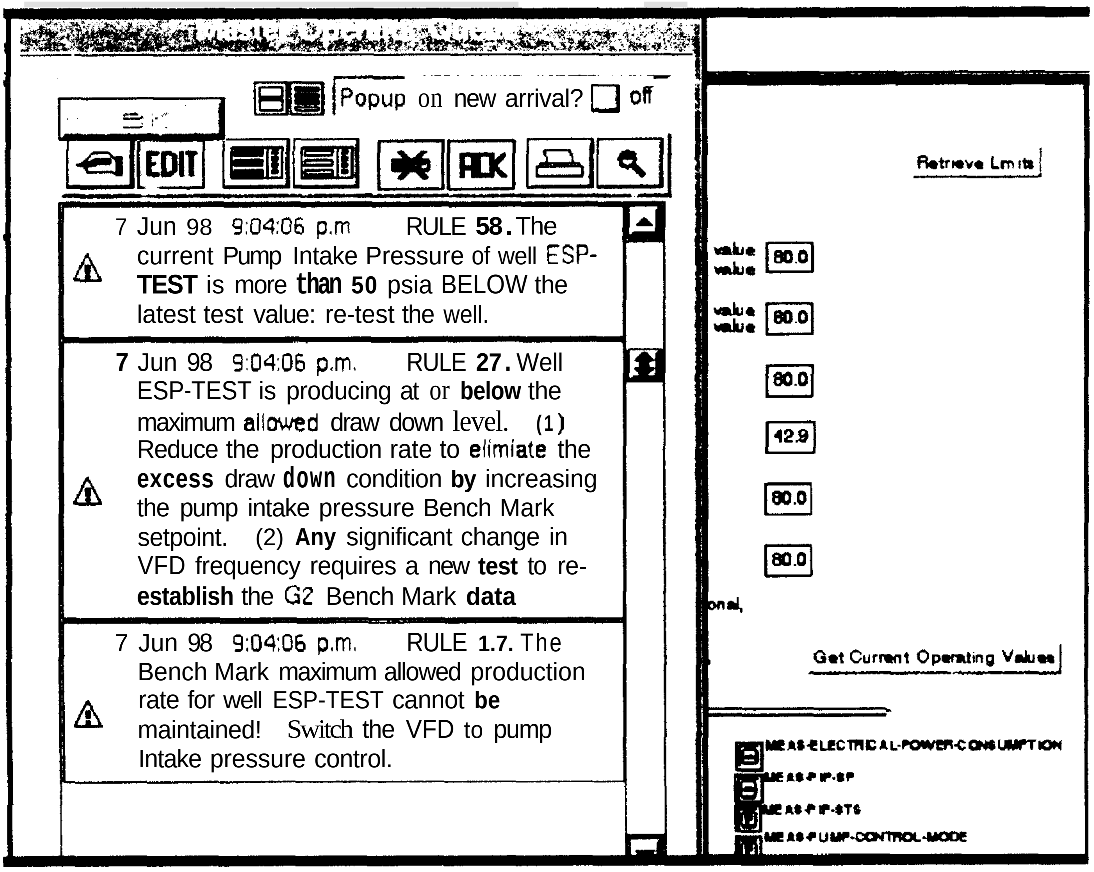

Figure 1

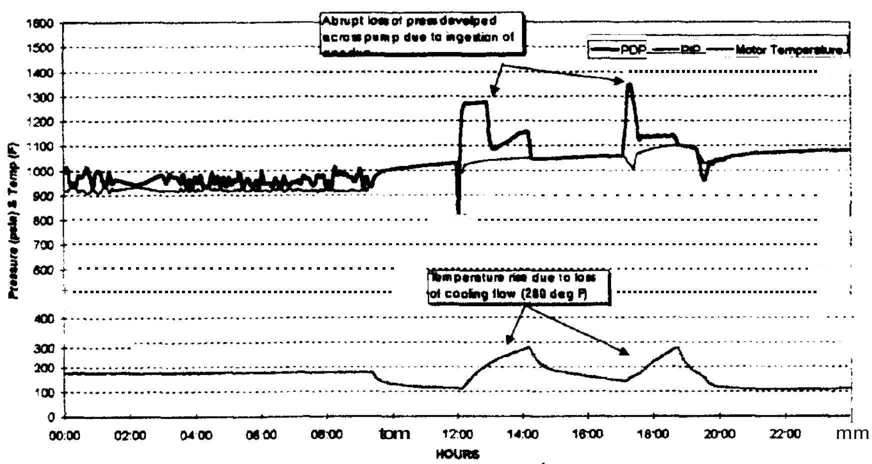

Figure 2

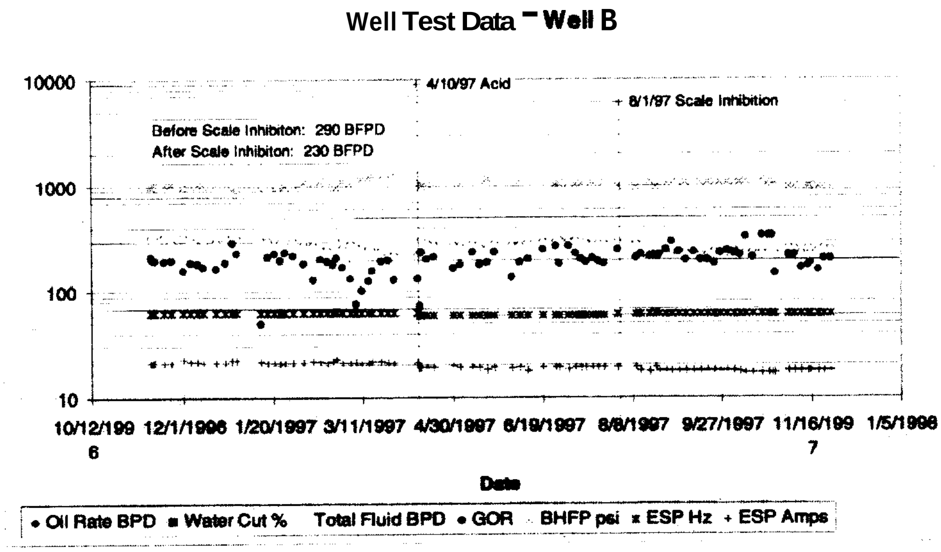

Figure 3

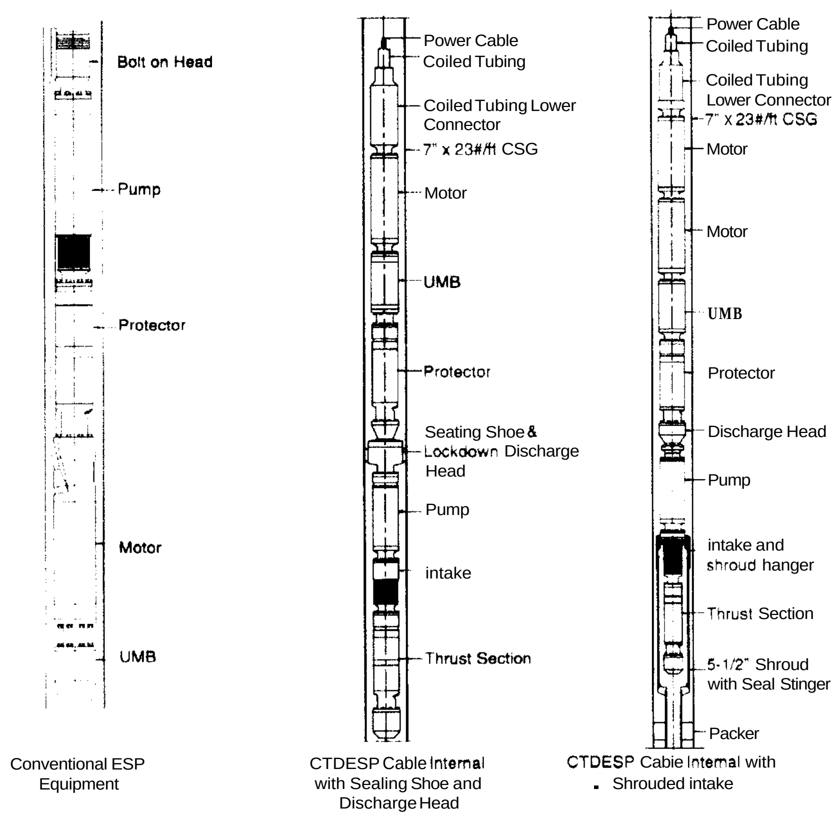

Figure 4

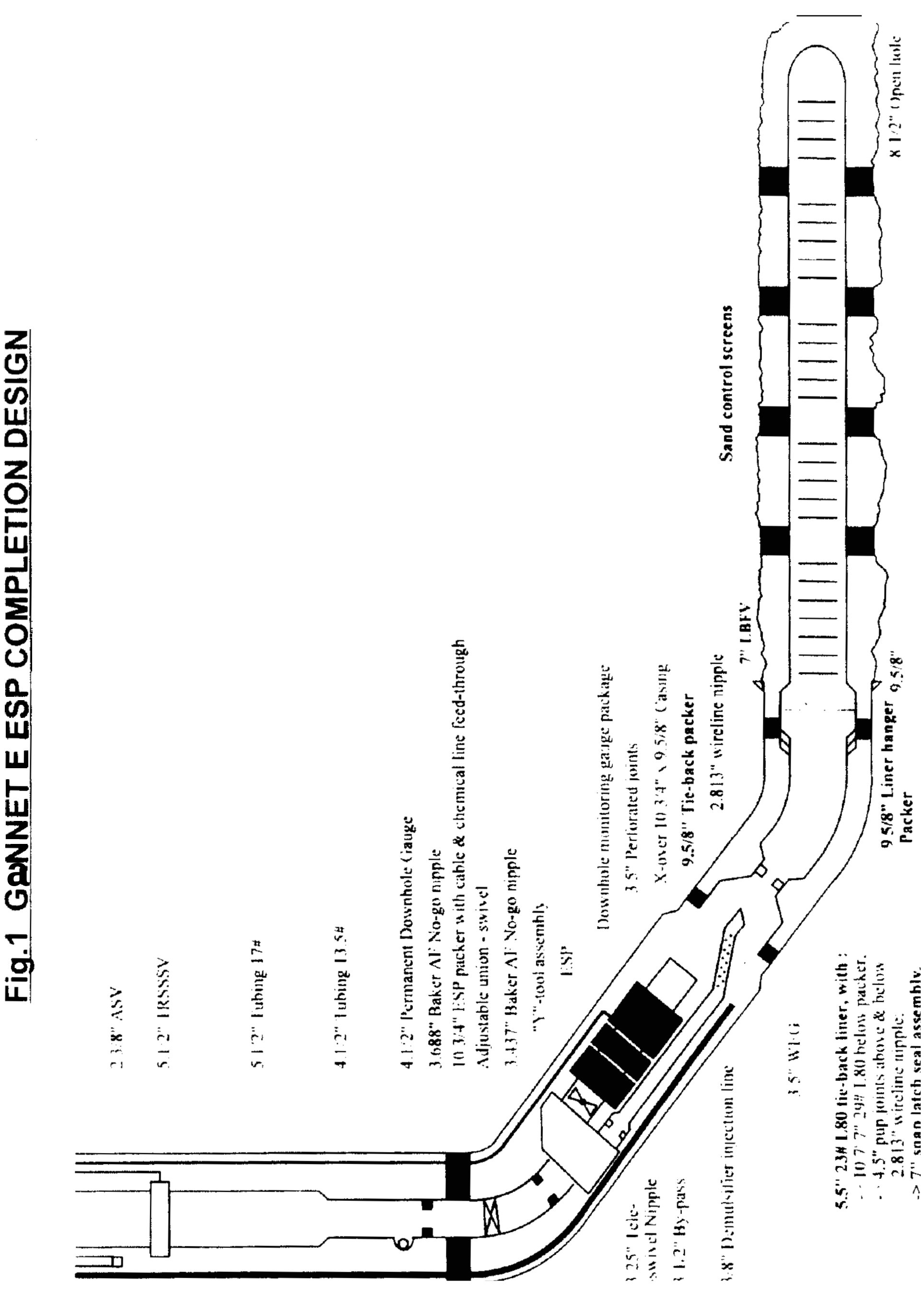
Fig.1 GANNET E ESP COMPLETION DESIGN
2 3/8" ASV
5 1/2" TRSSSV
5 1/2" Tubing 17#
4 1/2" Tubing 13.5#
4 1/2" Permanent Downhole Gauge
3.688" Baker AF No-go nipple
10 3/4" ESP packer with cable & chemical line feed-through
Adjustable union - swivel
3.437" Baker AF No-go nipple
"Y"-tool assembly
ESP
Downhole monitoring gauge package
3.5" Perforated joints
X-over 10 3/4" x 9 5/8" Casing
9.5/8" Tie-back packer
2.813" wireline nipple
7" LBFV
Sand control screens
3.25" Tele-
swivel Nipple
1.2" By-pass
8" Demulsifier injection line
3.5" WEG
5.5" 23# L80 tie-back liner, with :
- - 10.7' 7" 29# L80 below packer.
- - 4.5" pup joints above & below
2.813" wireline nipple.
-> 7" snap latch seal assembly.
9 5/8" Liner hanger
Packer
9.5/8"
8 1/2" Open hole

Figure 5

Panuke Dual Y-tool System

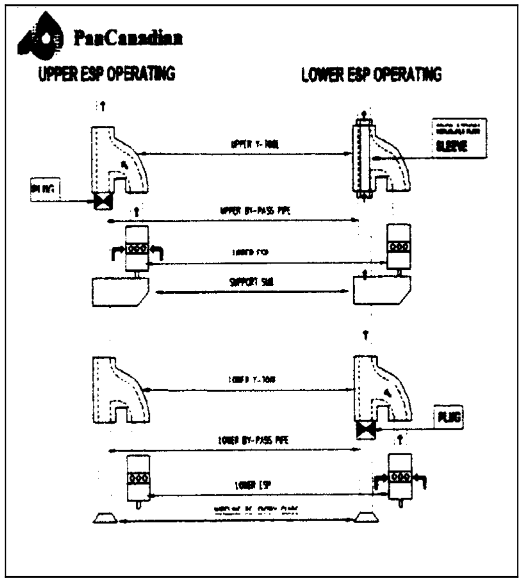

Figure 6

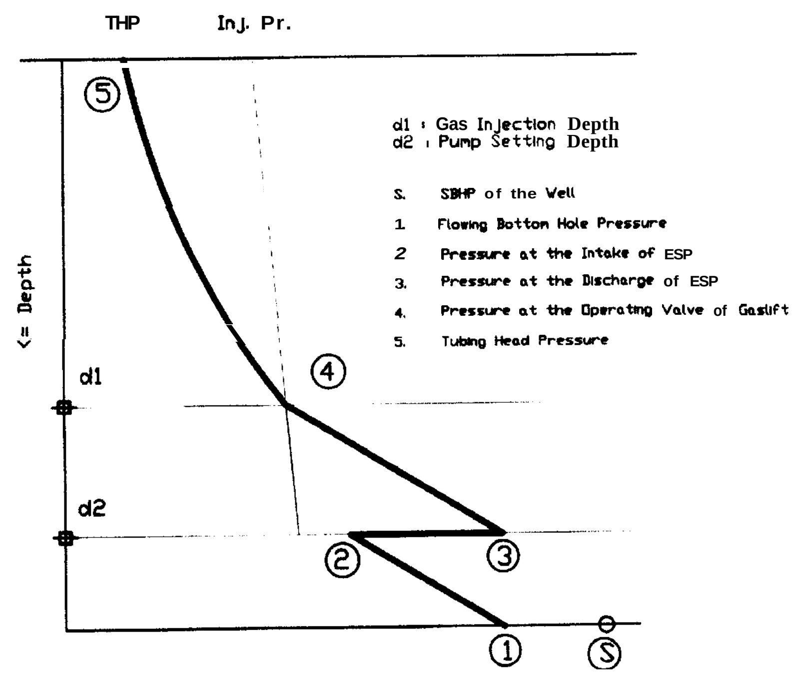

Figure 7 - Pressure Gradients in the Tubing with Combination Lift

Normal operating conditions:

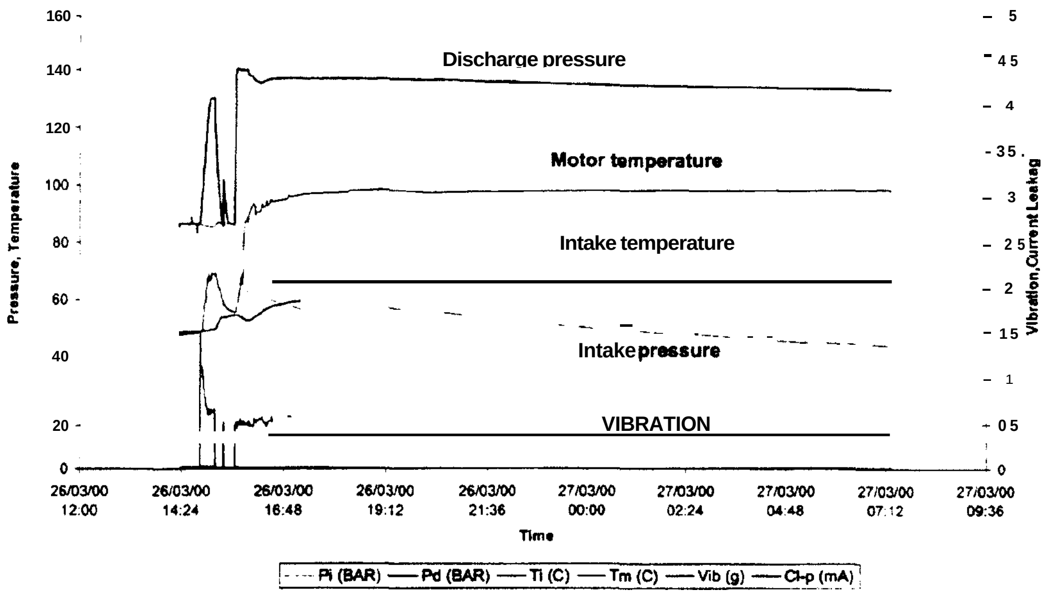

Figure 8

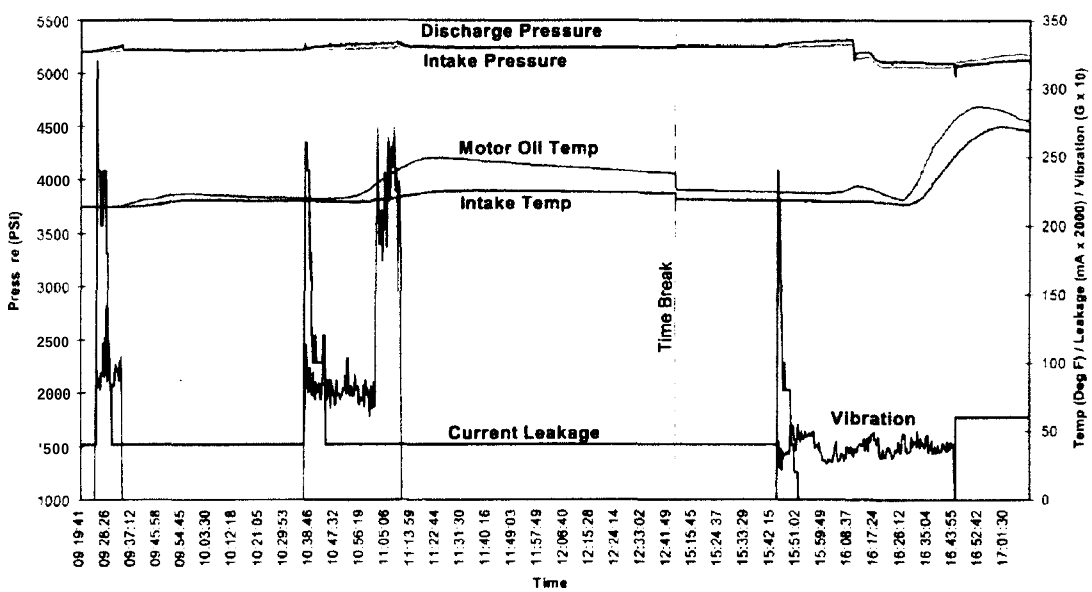

Figure 9