UNITED NATIONS **S**

Security Council

Distr.
GENERAL

S/1998/1233
29 December 1998

ORIGINAL: ENGLISH

LETTER DATED 29 DECEMBER 1998 FROM THE SECRETARY-GENERAL ADDRESSED TO THE PRESIDENT OF THE SECURITY COUNCIL

Pursuant to paragraph 9 of Security Council resolution 1210 (1998) of 24 November 1998, I have the honour to submit a detailed list of parts and equipment necessary for the purpose described in paragraph 1 of resolution 1175 (1998).

In order to help prepare the above-mentioned list, I dispatched a group of four experts to Iraq. The experts were provided by Saybolt Nederland BV. which, under a contract with the United Nations, has been providing independent oil inspection agents since the beginning of the humanitarian programme in Iraq pursuant to resolution 986 (1995). The group visited Iraq from 13 to 16 December 1998 to review the situation on the ground and, in consultation with the Government of Iraq, to prepare the list of spare parts and equipment necessary to enable Iraq to increase the export of petroleum and petroleum products, in quantities sufficient to produce the sum established in paragraph 2 of resolution 1153 (1998). The report of the group is also enclosed for your information.

As stated in my letter dated 15 April 1998 addressed to the President of the Security Council (S/1998/330) submitting the executive summary of the group of experts established pursuant to paragraph 12 of resolution 1153 (1998), as well as in my subsequent reports, including the most recent one submitted on 19 November 1998 (S/1998/1100) on the implementation of the humanitarian programme under resolution 986 (1995), the oil industry of Iraq continues to be in a lamentable state. It may be recalled that the group of experts had stated then that existing oil fields in Iraq have had their productivity seriously reduced, some irreparably, during the past two decades. They had also stated that a sharp increase in production without concurrent expenditure on spare parts and equipment would severely damage oil-containing rocks and pipeline systems, and would be against accepted principles of "good oilfield husbandry".

The report now submitted by the group of experts describes the further deterioration of Iraq's capacity to produce and export oil. Since the visit of the previous group of experts to Iraq in March 1998, the predicted decline in the overall oil production capacity of Iraq has continued at an estimated annual rate of 4 to 8 per cent. A significant number of wells have ceased production, both in the north and in the south, owing to the lack of water-removal

facilities. The group of experts estimates that approximately 20 per cent of those wells are irreparably damaged. The remaining wells, in their view, could be returned to production should appropriate spare parts be made available on a timely basis, thereby recovering approximately 100,000 barrels per day in production capacity. According to the group of experts, there is a possibility of a net increase in production capacity during the next six months, subject to the timely arrival of critical spare parts. They consider that the list of spare parts and equipment provided by the Government represents a pragmatic approach to sustaining, and eventually increasing, current production levels, albeit reflecting a continued reliance on outdated oil field development concepts.

By its resolution 1153 (1998) the Security Council authorized a substantial increase in exports of petroleum and petroleum products from Iraq and, subsequently, by its resolution 1175 (1998), the Council authorized an amount of $300 million for the purchase of oil spare parts and equipment under phase four of the humanitarian programme. However, the pace of approval of applications for spare parts and equipment has been slow. Unless Iraq is expeditiously provided with the essential oil spare parts and equipment, it may be difficult to sustain even the current level of production and export of oil. The implementation of the humanitarian programme has also been adversely affected by the substantial drop in the price of oil in recent months, resulting in a shortfall of over $1 billion out of the $3.1 billion required for the implementation of the distribution plan under phase four.

As at 28 December 1998, 447 applications, with a total value of $243.2 million, for spare parts and equipment for the Iraqi oil industry have been received, of which 392, with a total value of $182.7 million, were circulated. Of the total number of applications circulated, 238, with a total value of $133.6 million, have been approved by the Security Council Committee established by resolution 661 (1990), and 133, with a total value of $43.6 million, have been placed on hold. There remain 48 applications, with a total value of $60.5 million, which have not yet been circulated because of insufficient information provided by the applicants or because they require amendments to the distribution plan.

As indicated by the group of experts, the list of spare parts and equipment submitted to the Council is "reasonable" and covers the most essential requirements of the deteriorating Iraqi oil industry. It would be helpful, therefore, if the Council could request the Committee established by resolution 661 (1990) to proceed as expeditiously as possible in its consideration and approval of applications for oil spare parts and equipment submitted under phase four and phase five and to also review further all applications placed on hold. In this connection, it may be recalled that most of the spare parts and equipment requested require long delivery periods as they are not immediately available "off the shelf". The Office of the Iraq Programme stands ready to assist the Committee in providing any additional information, including technical advice, that may be required.

(Signed) Kofi A. ANNAN

Annex I

Report of the group of experts established pursuant to paragraph 9 of Security Council resolution 1210 (1998)

A. Terms of reference

1. In paragraph 9 of its resolution 1210 (1998) of 24 November 1998, the Security Council requested "the Secretary-General, in consultation with the Government of Iraq, to submit to the Council, by 31 December 1998, a detailed list of parts and equipment necessary for the purpose described in paragraph 1 of resolution 1175 (1998)." The terms of reference for the group of experts included: the breakdown of upstream and downstream operations, and their interrelationship; an indication of the effect of each line item or project on sustaining current production as well as increasing production; an assessment of the impact of spare parts and equipment made available under phase four on both sustaining and increasing production; clarification of long-term spare parts requirements; and an explanation or definition of nomenclature for spare parts (namely, numbers, lots, sets, measurements).

B. Introduction

2. At the request of the Secretary-General, a group of experts visited Iraq to ascertain the current requirements for spare parts and equipment in relation to Iraq's ability to sustain current export capacity of crude oil and also to review and further assess the potential for increased exports.

3. The group of experts visited Iraq from 13 to 16 December 1998 and met with relevant authorities, particularly the Ministry of Oil, and representatives from all operating companies in the oil sector in order to finalize the list of oil spare parts and equipment.

4. Since the visit of the group of experts to Iraq in March 1998, the predicted decline in the overall oil production capacity of Iraq has continued in the estimated range of 4 to 8 per cent of total production per annum.

5. A significant number of wells have ceased production in both the north and the south, owing to the lack of water-removal facilities. Approximately 20 per cent of those wells are irreparably damaged. The others could be returned to production, with appropriate spare parts, thereby recovering approximately 100,000 barrels per day (bpd) of production capacity.

6. The proposals made by the Government of Iraq to increase production to meet the $5.256 billion ceiling per 180-day phase are innovative and practical, given the existing constraints. The list of spare parts and equipment given to the group of experts by the Government of Iraq for phase V are deemed reasonable. The drilling of replacement production wells in several of the larger oil fields, together with cleaning out and overhauling old wells so that they will produce more oil, and improvements to the downstream systems, should succeed in replacing oil volumes which have been lost through the processes described above.

7. There is a possibility of a net increase in production capacity during the next six months, but this is dependent on the timing of the arrival of critical spares. However, it must be noted that the entire programme for the oil industry of Iraq is out of step with modern engineering techniques and generally accepted principles of "value for money" investment. The phase V list of spare parts reflects a proposed expenditure on valid items, but it relies on outdated oil field development concepts. It is extremely unlikely that the Iraqi oil industry will ever meet the planned production targets associated with the oil-for-food programme, within the current constraints.

8. An approach recommended by the group of experts would be the implementation of a programme to drill horizontal wells (rather than the present vertical ones) to substantially increase production performance, minimize the influx of water and restrict damage to the reservoirs. The list of spare parts and equipment required for such an approach would differ significantly from the list submitted for phase V, but would represent an optimal return on funds available.

9. Since the previous visit by the group of experts in March 1998, the oil industry of Iraq has been reorganized into 13 separate operating companies, each of which has been allocated funds by the Government of Iraq for spare parts under phase V of the oil-for-food programme, as follows:

Company name	Allocation
	(United States dollars)
North Oil Company	85 000 000
South Oil Company	100 000 000
Iraqi Drilling Company	20 000 000
Oil Projects Company	10 000 000
Oil Exploration Company	5 000 000
North Refineries Company	32 000 000
Midland Refineries Company	10 000 000
South Refineries Company	5 000 000
North Gas Company	4 000 000
South Gas Company	4 000 000
Oil Products Distribution Company	10 000 000
Oil Pipelines Company	5 000 000
Gas Filling Company	10 000 000
TOTAL	300 000 000

10. The Government of Iraq declined to specify the individual prices of specific items, projects or grouping of spare parts beyond advising on the allocation of funds within the $300 million allocated under resolution 1210 (1998).

C. Overview

11. Current oil production is estimated at 2.5 million bpd. Current local consumption is said to be 550,000 bpd, and 70,000 bpd are still exported to Jordan, leaving 1,880,000 bpd available for export.

12. The average exported volume under phase IV was 1,712,000 bpd.

13. The Ministry of Oil predicts that, at best, production can only be sustained at a level of 2.5 million bpd until the spare parts procured under phase IV have been received and installed, and crucial spare parts to be ordered under phase V arrive and have been installed. Any increase in production over current levels is thought unlikely to be achieved until March 2000, after which export capacity is expected to increase in incremental steps as the effects of certain projects (for example, water injection) are realized.

14. The Ministry of Oil advises that production difficulties are currently being experienced. In the north, production has been lost from 25 wells because of water problems and it is estimated that production will be lost from another 30 before spare parts ordered under phase IV arrive; and in the south, production water problems are coupled with pressure maintenance resulting from a lack of water injection. It must be recognized that while the main objective is at least to sustain current production levels beyond phase V, irreparable damage is meanwhile being done to producing wells.

D. Spare parts and equipment

15. The list of oil spare parts and equipment for phase V is submitted in 13 sections, subdivided by operating companies, each with an allocation of funds determined by the Government of Iraq. These allocations have been made on the basis of perceived need, taking into account current production problems.

16. There is no allocation for the Iraqi State Organization for the Marketing of Oil (SOMO) as there are no requests from this company.

17. The overall objective in determining spare parts and equipment within phase V is to sustain current oil production levels. As production is being lost to wells watering out, and as the ability of the industry to treat crude oil prior to export (for example, de-gassing, de-watering) is limited because crucial spare parts have yet to arrive and be installed, the Government of Iraq has moved toward prioritizing projects to compensate for lost production. This is coupled within phase V with certain projects which would increase the volume of oil available to sustain production and eventually increase crude oil exports.

18. Specific reference to the relevance and rationale for the selection of spare parts and equipment is made in the following sections, which provide greater detail of the spare parts requirements for each operating company. The list provided by the Government of Iraq under the distribution plan for phase V was updated as a result of discussions held in Iraq during the visit of the group of experts. Comments have been provided per line item, as appropriate.

North Oil Company - $85,000,000

19. The current stated production capacity of the North Oil Company of Iraq is 1,197,000 bpd, which includes 20,000 bpd from Saddam Field. In the last eight months, a further 25 wells have started to produce water and oil and have been shut down (mainly in Kirkuk and Bai Hassan). The trend towards wells becoming water-wet indicates a further 30 wells may be expected to be shut down during phase V. The arrival and continued supply of de-watering chemicals should alleviate one aspect of the problem, and allow the reopening of most of these wells.

20. However, some permanent damage has been done to the wells by the influx of water, and without the facilities for overhaul, the only solution has been to close the affected wells.

21. The quantities of chemicals and other materials necessary for the drilling of 25 replacement wells in Avaneh Dome (Kirkuk Field), Khabbaz and Bai Hassan) are deemed reasonable. At current market prices, these elements represent about one-third of the cost of spare parts for the North Oil Company (namely, between $25 and $30 million). A limited amount of old wellheads, etc., are available in the North Oil Company’s stocks; hence, there is a lesser spare parts requirement than would be expected for the number of supplemental production wells that are proposed.

22. It is impossible to envisage a "value-for-money" investment in these activities without a technical evaluation and the use of control equipment. Thus, the requests for spare parts and equipment for well-perforating, geological laboratories, coring, reservoir simulation facilities, wire line units, etc., should be considered within the context of the overall application of funds. These activities could be covered at current prices with $5 to $7 million.

23. It should be noted that the 25 vertical wells proposed will not increase production capacity but might sustain the levels achieved in phase IV because they will penetrate oil columns which are known to have been reduced in vertical extent. The oil-water contacts have been moving upwards through the reservoirs as depletion takes place, and the water underneath flows into the perforations in the production pipe. The surface facilities are very sensitive to the water content in the oil, and cannot function in certain cases with more than 0.5 per cent water content. The arrival of phase IV de-watering chemicals will allow a number of wells to be reopened if they have not been damaged by the effects of the reservoir water on the flow properties of the oil-producing rocks.

South Oil Company - $100,000,000

24. The North Rumaila Field redevelopment project, which includes the overhaul of 50 existing wells, the drilling of 25 new water injectors and 15 new wells, is projected to result in a 200,000 bpd improvement in production capacity. The spare parts and equipment requirement for this project is not unreasonable, and the drilling and well-completion materials are estimated to constitute about half the amount estimated (namely, $50 million). The wells are deeper than those in the north and thus give rise to a higher expenditure per well.

25. It is impossible to envisage a "value-for-money" investment in these activities without a technical evaluation and the use of control equipment. Thus, the requests for spares for well-perforating, geological laboratories, coring, reservoir simulation facilities, wire line unit, etc., should be accepted in the context of the overall application of funds. These activities could be covered at current prices with $7 to $9 million.

26. The same comments apply in the south as to the North Oil Company regarding the cost-effectiveness of providing spares for a vertical drilling solution to the ever-deteriorating production capacity. If horizontal wells were to be used, fewer wells than in the phase V proposals would be required to both sustain and increase oil production. The nature of the spare parts and equipment required for surface facilities would not change, but the reservoir assessment and development drilling spare parts list and prices would have to be revised.

Iraqi Drilling Company - $20,000,000

27. The need to drill extra production wells, water-injection wells, and to overhaul existing oil producing wells, creates a demand for expertise in this area. A number of relevant facts were gathered concerning the drilling company and other facilities when the group of experts was visiting nearby sites.

28. In particular, most rigs were observed to be in a lamentable state and to have fallen into disuse since 1990. The spare parts and equipment proposed for 20 rigs to complete the programmes in the north and south would cost more than the proposed expenditure if purchased new.

Oil Projects Company - $10,000,000

29. This company is involved in construction projects on behalf of the operating companies throughout Iraq and acts as a contractor. Its requirements therefore cover the whole spectrum of construction, maintenance and testing of new and repaired structures, including non-destructive testing (NDT). The list of spare parts and equipment includes NDT equipment, project management software, and standards, construction and maintenance equipment.

Oil Exploration Company - $5,000,000

30. The entire reservoir management concept (namely, the need to replace lost wells and to address declining production with infill producing wells, water-injection wells and overhauled wells) which serves as the rationale behind the

list of spare parts and equipment for phase V, requires information about the rock structure and the position of oil and water within the reservoirs. All the items listed are prerequisites for successful field rehabilitation and development programmes and are deemed essential. The level of funding requested is probably insufficient to cover all of the projects envisaged, and it is unlikely to result in a much-increased ability to determine where to drill or to inject water, or which wells would benefit most from overhaul.

31. The list of spare parts and equipment for the Oil Exploration Company represents an integrated whole, and the deletion of any item would undermine the value to be obtained from those items under phase V.

32. Technical training and support are normally provided with the delivery of spare parts and equipment, and included in the prices quoted by suppliers. Many of the items will be useless without some form of assistance to analyse the data obtained and thereby design a meaningful production-enhancement programme.

North Refineries Company - $32,000,000

33. The Baiji Refinery sustained heavy damage in past conflicts yet remains the largest and most modern refinery in Iraq, and it is a key component in the production of refined petroleum products. The list of spare parts and equipment for this facility is based on two main projects, and general repairs and maintenance:

(a) Hydro cracker unit. The primary function of the hydro cracker unit is to convert surplus fuel oil into gasoline and diesel fuels that would otherwise be in shortage. The repair of this unit will result in products (particularly gasoline, kerosene and gas oil) of better quality. This will allow power plants to burn fuel oil rather than crude oil, as at present, releasing an estimated 60,000 bpd of crude oil for export; the refined products will have a much lower sulphur content and will also reduce environmental damage;

(b) Waste water treatment plant. This badly damaged unit, with spare parts already approved under phase IV, requires further work before completion and will significantly reduce the oil content of effluent water discharged into the Tigris River and the surrounding water table;

(c) Mechanical equipment spares and spare parts kits. Similar to spare parts for this facility under phase IV, this list of spare parts and equipment covers numerous repairs to the rotating and static equipment in the refinery and again will significantly impact the quality of refined products produced. In particular, the supply of fuel oil to the adjacent power plants to replace its current usage of crude oil will release 100,000 bpd of crude oil for export.

Midland Refineries Company - $10,000,000

34. The Daura Refinery is situated in the outskirts of Baghdad. The spare parts and equipment listed are intended for repairs to the water treatment plant, lubricating oil plant, and general repair and maintenance. The expected effect of the proposed repairs would be an increase in the availability of crude

oil for export of up to 60,000 bpd, and an increase in the production of reasonable quality lubricating oil to 100,000 tonnes per annum:

(a) Water treatment plant. A complete water treatment unit is necessary, which would improve the quality of effluent water released directly into the Tigris River in the immediate vicinity of Baghdad;

(b) Spare parts for lubricating oil plant. The quality of lubricating oil produced in Iraq remains extremely poor, resulting in significantly shorter maintenance periods, breakdowns and increased consumption.

South Refineries Company - $5,000,000

35. The Basrah Refinery, situated in the south, has been severely damaged. The list of spare parts and equipment for this facility seeks to address several vital issues, including the provision of better quality drinking water for the oil industry workers, safety issues, and the upgrading of the quality of refined products releasing crude oil for export:

(a) General spare parts for rotating machinery. The installation of these spare parts will allow the production of increased quality products (gas oil and fuel oil), which can be substituted for direct crude oil usage. The predicted net compensation effect on completion of the installation of these spare parts will eventually be 50,000 bpd;

(b) Upgrading of potable fresh water system and transportation to site. The normal drinking water available in the Basrah region is both unsafe and unreliable. The spare parts allocation covers repairs to the water treatment facility and tankers for delivery of this water to working sites in the southern refineries area;

(c) Instruments for environmental protection. The spare parts and equipment under this group are intended to cover laboratory equipment, especially gas analysers, to provide improved safety and environmental control of refinery operations.

North Gas Company - $4,000,000

36. For the Kirkuk region, the list of spare parts and equipment is intended for the gas treatment plants in the north, which are utilized to extract gas from the crude oil prior to export. Sustaining the operation of these plants and increasing their efficiency will allow increased effectiveness in the treatment of crude oil, thereby increasing the amount of gas extracted, which can then be used as a power source in power stations, consequently enhancing the volume of crude oil available for export.

South Gas Company - $4,000,000

37. For Basrah, the list of spare parts and equipment is intended for the gas treatment plants in the south, potable water transportation equipment, safety equipment and the construction of a 25-kilometre pipeline in the Anzalah region. Construction of this line will allow transfer of crude oil from the southern

production area to the north, and from there for export via the Kirkuk-Yumurtalik pipeline to Ceyhan.

Oil Products Distribution Company - $10,000,000

38. This new company has been set up to increase the efficiency of product distribution throughout the country. As a result of severe damage to the products pipeline distribution network in certain areas, and the large geographical area covered, refined product distribution is currently undertaken mainly by vehicular transport.

39. Spare parts and equipment for this facility include vehicles, fuel dispensers, meters and associated equipment, electrical equipment spares and the construction of a number of large storage tanks at key sites.

40. The expected benefit of the spare parts indicated will be to significantly reduce leakages, which account for some 7 per cent of the volume of products distributed, with obvious associated environmental effects. Reduction of these losses (some as simple as leaking washers on fuel dispenser pumps) will reduce the refined oil product requirement, releasing crude oil for export.

Oil Pipelines Company - $5,000,000

41. This list of spare parts and equipment covers repairs to oil depots, pumping stations and the pipeline network designed to distribute refined oil products throughout Iraq. As a result of significant damage, much of the product distribution is currently undertaken by road vehicles, which is inefficient, dangerous and unreliable; repair and maintenance within this sector is essential.

Gas Filling Company - $10,000,000

42. Much of the list of spare parts and equipment includes repeat items for the Gas Filling Company which were applied for under phase IV but for which insufficient funds were available. There are approximately 12 million liquid propane gas (LPG) cylinders in Iraq that are 10 to 30 years old. Normal cylinder life span is 15 years maximum, backed by annual individual cylinder pressure testing, which is not currently done in Iraq. In Iraq, each cylinder is filled about 10 times per annum, whereas international standards indicate an average of five to seven times per annum. The Gas Filling Company also repairs damaged cylinders, which is prohibited internationally. Approximately 250,000 cylinders are destroyed annually and, with the exception of those requested under phase IV, no new cylinders have been purchased since 1989.

43. The list includes 500,000 replacement cylinders, spare parts, safety and maintenance equipment, and chemicals to assist in the detection of LPG cylinder leaks.

E. Conclusion

44. The general opinion of the group of experts is that the list of spare parts and equipment provided by the Government of Iraq represents a pragmatic approach to sustaining, and eventually incrementally increasing, current production levels, albeit reflecting a continued reliance on outdated oil field development concepts.

45. With reference to the report of the group of experts on their mission in March 1998, it may be said that so far no significant improvements have been made, mainly because of the fact that actual deliveries of spare parts and equipment ordered under phase IV are only starting to take place now. The group of experts shares the opinion of the Iraqi Ministry of Oil that it is unlikely that an increase in production will be achieved before March 2000. The main objective of the Government of Iraq at this time is to sustain current production levels through and beyond phase V.

46. Finally, the group noted that there appears to be duplication in many cases between the list submitted for phase IV, and the list for phase V. The reason for this apparent duplication is that, as stated in the previous report of the group of experts, the prices of the requested spare parts and equipment for phase IV were marginally higher than estimated and would have resulted in the exceeding of the allocation of $300 million for spare parts and equipment.

Appendix

Petroleum engineering glossary

Horizontal wells

The engineering approach to developing oilfields evolved significantly in the early 1990s with a conceptual leap which was stunning in its simplicity. Some degree of technical innovation accompanied the switch from drilling vertical holes in the ground to the idea of "turning" the well as it progressed until it intersected the oil-containing layers and drilled along them rather than through them. The techniques for creating so-called "deviated" wells had been employed since the late 1960s, but improvements in drilling equipment and materials were necessary before it was proved that the well-bore could remain in the oil-containing horizontal layers, and avoid the water below, by staying horizontal.

Hydro cracking

Hydro cracking plays a crucial role in crude oil refining whereby clean transportation fuels are made out of residual oil fractions.

Infill drilling/infill wells

Most oilfields in Iraq cover tens of square miles in extent, and the oil-producing layers are at relatively shallow depths, especially in the north. The conventional method of tapping the oil has been to drill wells straight down to the reservoirs; wells in the large Kirkuk field are spaced about 3,000 feet apart (that is, more than half a mile). When some of these wells start producing water, which cannot be handled at the surface facilities, they are shut down. In order to efficiently drain the reservoir volumes between these widely-spaced points, infill wells are drilled, because there is at least a 90 per cent probability that a new vertical well will also penetrate an oil-rich layer of rock.

Injected water

As oil is drawn off the reservoir, the pressure gradual declines, and the productivity index (and rate of production) also falls away, often exponentially downwards. It is possible to significantly delay this process by injecting either gas and/or water into the reservoir to achieve a degree of pressure-maintenance. Often, the water is injected in very large quantities into the bottom periphery of the reservoir to assist in optimizing the recovery of oil. This water must be treated with biocides, filtered and then pumped at great pressure to be effective.

Injection wells

The wells that are used for pressure maintenance, whether gas or water.

Oil production capacity in barrels per day (bpd)

The optimum total volume of oil that Iraq can produce during a given 24-hour period from approximately 450 wells in 24 oilfields, under ideal conditions, if there are no pipeline leaks, treatment facility breakdowns, or shortages of de-gassing equipment and de-watering chemicals.

Oil well productivity index (PI)

A measure of the daily amount of fluids which an oil well can produce per unit of reservoir pressure. Usually, a horizontal well in a given oil reservoir will have a PI far greater than that of a vertical well penetrating the same reservoir; often a horizontal well will be from 2 to 10 times more productive than its vertical neighbour.

Perforating

In order to allow oil to be produced from a reservoir, it is necessary to provide a flow-path from the bottom of the well to the surface production facilities. By lowering a bundle of small, shaped, explosive charges down the well on a wire-line, it is possible to "shoot" holes in the foot of the casing so that the reservoir rocks are connected to the well proper.

Produced water

Most Iraqi oil reservoirs also contain vast aquifers of saline water upon which the oil floats. The reservoir consists of various types of porous rock which contain the oil and the water. Initially there may also be a volume of gas trapped above the oil. As oil is drawn out of the reservoir, the water moves to occupy the space left. If the oil is produced too quickly or over a great length of time, the reservoir water also starts to appear in the fluid produced from the well; the oil is said to be "wet crude" or "water-cut".

3-D seismic

In order to accurately define the whereabouts of the layers of oil-bearing rocks, once an oilfield has been discovered, modern techniques using sound-waves are applied on a fairly close-gridded spacing over the entire surface area of the field. A three-dimensional "picture" of the subsurface rocks is generated which can help identify the best places to drill horizontal wells and achieve the optimum production rates and recovery from the reserves of hydrocarbons in the rocks below.

Wire line unit

Once oil wells have been drilled, they are lined with steel tube (casing) and other equipment to enable the flow of produced fluids to be controlled and measured. As time passes, the equipment "downhole" may corrode and require replacement. The easiest method of changing valves, etc. (which may be located several thousand feet down the well), is to lower various tools on a thin wire cable into the well, and pull the offending items out. The equipment used to

perform this work is a wire line unit (a very long length of cable wound on a motorized drum).