LNG 1 PLANT REVAMPING PROJECT: IMPROVEMENT AND DEBOTTLENECKING

PROJET RENOVATION COMPLEXE GL1-Z: AMELIORATION ET LEVEE DES GOULOTS D'ETRANGLEMENT

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ABSTRACT

As part of the decision to reinstate an LNG export programme, it was decided to renovate the GL.1Z Complex situated in the industrial area of Arzew, Algeria, to produce LNG to the Nominal LNG Production Capacity for 330 days/annum and, after removal of bottlenecks, to increase the capacity.

- What were the modifications/improvements made to achieve the Nominal LNG Production?
- What were the bottlenecks and how were they overcome?
- What was the project execution methodology?
- What were the financial sources and how were material and manpower resources mobilised?
- What were the main constraints?
- What is the cost aspect of this renovation work?

These are some of the questions we have tried to answer in this paper.

RESUME

Dans le cadre de la relance du programme d'exportation de GNL, le Complexe GL1Z, situé dans la zone industrielle d'Arzew, Algérie, devait être rénové en vue de produire selon la Capacité Nominale de Production pendant 330 j/an et, aprés la levée des goulots d'étranglement, augmenter cette capacité.

- Quelles ont été les modifications/ameliorations apportées aux installations en vue d'atteindre la Capacité Nominale de Production ?
- Quels ont été les goulots d'étranglement ?
- Quel a été le programme de réalisation ?
- Quelles ont été les principales difficultés rencontrées ?
- Quel a été l'aspect du coût de cette opération ?

Telles sont les questions auxquelles nous avons essayer de répondre dans la présente communication.

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I) PLANT DESCRIPTION

The Liquefied Natural Gas complex GL.1Z is situated in the industrial area of Arzew, in north west coast of Algeria. The complex GL.1Z uses the APCI Multi Component Refrigerant (MCR) process. The Plant first came into production on 24 February 1978 and comprises the following:

- A production area consisting of six (6) identical natural gas liquefaction units or trains.
- A utility area comprising of systems for producing steam, electricity, desalinated water, de-mineralised water, instrument air and nitrogen.
- A storage and transfer facility.

II) PRE-RENOVATION BACKGROUND OF GL.1Z COMPLEX

GL.1Z complex had not been operated to the full production capacity for which it was designed, due to various problems and bottlenecks since its first commercial production on 24 February 1978.

Production History

The following table delineates the actual production achieved since February 1978 and prior to commencement of renovation works.

Table 1 Yearwise Production of GL.1Z Complex

YEAR	PRODUCTION wrt CIC (%)
1978	22
1979	68
1980	23
1981	13
1982	21
1983	38
1984	31
1985	36
1986	34
1987	39
1988	42
1989	42.6
TOTAL	**N/A**
AVG. PER YEAR	**34**

Table 1 shows that maximum production of 68% of Nominal LNG Production was achieved in 1979 and the average production from 1978 to 1989 (i.e. pre renovation) works out to an average percentage of 34% wrt to Nominal LNG Production.

Number of Shutdowns

Lack of reliability of equipment during operating years of the Complex necessitated numerous shutdowns of installations. The shutdowns gradually increased through time during the operating years of the Complex and its frequency reached the maximum level during the two years prior to the renovation works, Phase - II and III. The frequency of the shutdowns occurred at an average rate of one shutdown per Train after every three (3) days during that period. Table 2 shows the total number of trips during 1989 and 1990, two years before initiation of construction works for renovation of GL.1Z complex.

Table 2 No. of Shutdowns 2 Years Before Renovation

YEAR	1989	1990
NUMBER OF SHUTDOWNS	130	110

Rate of Autoconsumption Yearwise

Lower production of GL.1Z Complex during the operating years, prior to initiation of the renovation works was compounded by higher rate of autoconsumption than that for which the plant was designed. The autoconsumption rate as per the Table 3 shown below infers that the design rate of 14.7% had not been reached during the operation of the Complex prior to the initiation of renovation works.

Table 3 Rate of Yearly Autoconsumption Prior to Renovation

YEAR	79	80	81	82	83	84	85	86	87	88	89	90
RATE %	25	29	27	35	31	29	22	24	22	19	21	20

Factors Influencing Production Loss

Continuous low production of LNG and escalating frequency of trips became a major concern for Sonatrach. It was identified that the loss of production was caused largely due to unreliability of critical process equipment mainly turbines and compressors, shortage of steam and delayed maintenance. Table 4 gives the percentage contribution of equipment and systems towards loss of production.

Table 4 % Contribution Towards Loss of Production

DESCRIPTION	ESTIMATED PRODUCTION LOSS (%)
TURBINES AND COMPRESSORS	37
STEAM	28
SEA WATER SYSTEM	14
MAIN EXCHANGERS	13
POWER GENERATION & DISTRIBUTION	7
UTILITY AIR SYSTEM	1
TOTAL	**100**

Safety Aspect of the Installations

The analysis of the situation as far as safety concerned revealed a situation detrimental to the operation of the facilities and systems (hydrocarbon leaks, unavailability of safety pumps, etc.). It was, therefore essential to give necessary importance to safe operations of the Complex and due considerations were given while finalising the renovation work scope.

III) RENOVATION PROGRAM

Viability

The analysis of the operating condition of GL1.Z Complex led Sonatrach to take actions aimed at supporting the LNG export boosting program decided to go ahead with the renovation of the Complex.

The feasibility study developed by Sonatrach demonstrated the profitability of the renovation program and the main points deciding in favour of renovation are as follows:

a) Current positive net value representing 98% of the updated investment cost.

b) Short acceptance time: five (5) years after the provisional acceptance.

c) The increased LNG production to allow Sonatrach in fulfilling its commitments to its customers.

Financing

The success of the renovation program was largely conditional on the mobilisation of credits and various financing packages which required an intensive co-ordination activity. This financing, considered within the context of the situation prevailing at that time, was a real challenge given the size and the complexity of the renovation program.

The requirements of financing, both in local and hard currencies, involved sourcing and mobilising considerable financial resources at the internal level (Self-financing) and at the external level (foreign credits). With the purpose of resolving this concern, the first action consisted in developing a Financial Brochure describing the GL1.Z Complex Renovation Project plan. This document provided an exhaustive information on Sonatrach's creditworthiness to the credit agencies and proposed the ongoing demand for financing. Finally the finances mobilised for the renovation project represented as a percentage of the total finance is shown in Table 5.

Table 5 Financing Breakdown of GL.1Z Renovation Project

SL.N°	FINANCING	PERCENTAGE
1	US EXIM	61.1
2	JAPAN EXIM / NISSHO IWAI	17.8
3	UK - E.C.G.D.	10.1
4	SONATRACH CASH LETTER OF CREDITS (L/Cs)	6.2
5	CANADA - E.D.C.	2.8
6	BELGIUM - DUCROIRE	2.0

IV) SCOPE OF RENOVATION WORK

The aim of the work undertaken during the GL 1Z renovation project was to improve safety, reliability, and autoconsumption. The LNG output of the plant has been increased to approximately 109% of the Nominal LNG Production capacity.

Scope outlines the major work that has been carried out to achieve the aim and are as follows:

Safety

Critical relief valves have been duplicated to enable valves to be maintained while the Plant is on stream.

Relocation of Gasoline Storage: A new gasoline storage sphere has been installed and the hydrocarbon decanter has been relocated adjacent to the new sphere.

The LNG storage tanks and the LNG pumps have had new isolating valves installed. A new LNG pump pit has been provided.

The existing fire water pumps have been replaced.

The existing foam system at the LNG manifold and the LNG pump pit has been replaced. A new foam system has been installed on the jetty.

New dry powder systems have been installed in the LNG storage area and the jetty.

A new fresh water deluge system has been installed.

The existing fire and gas detection systems have been renovated and modified. The system interfaces with the ESD system.

Emergency isolation and depressurising facilities have been installed.

Replaced corroded piping, pipe supports, isolation valves and insulation.

Reliability

A Distributed Control System (DCS) has been installed for total control of the plant along with construction of a new building to accommodate the same.

Two new instrument air compressors have been installed.

The existing sea water pumps and motors have been replaced by new equipment, to provide sufficient cooling water for the enhanced capacity.

Two new electrochlorination units have been installed to provide the requirements of both GL.1Z and GL.2Z. The existing sea water booster pumps feeding the chlorination units have been replaced.

New desalination units have been installed to replace three of the existing units. A demineralisation unit has been installed.

The electrical distribution system has been modified to include connection to the national power grid of 60 kV supply.

Four new process boilers of 400 tph each have been installed and a new boiler management system has been installed in new and existing process boilers.

The existing LNG loading arms have been replaced by new arms.

New MEA pumps and motors have been installed to replace the existing standby pumps on all six trains. These pumps are connected into the existing suction and discharge piping and the existing motors are retained. The MEA pump turbines have been replaced by new turbines on all trains.

The top two trays, trays 1 and 2, in the MEA absorber wash water system, have been replaced by new trays and a new chimney tray has been installed between trays 2 and 3. Two new wash water pumps have also been installed.

A new MEA flash drum has been installed. The function of this item of equipment is to flash off hydrocarbon vapours from the rich MEA solution before the MEA enters the regenerator. It also provides for the separation of any hydrocarbon liquid which may be contaminating the MEA stream. The overall function and operation of the MEA system remains unchanged by the addition of the wash water system and the MEA flash drum.

A Mercury Removal vessel and associated filters have been installed in the Dryer System between the dryers and the feed propane chiller.

The existing Fuel Gas, Propane and MCR Compressor Anti-Surge Systems have been replaced by a new PLC based System for each, located in the anti-surge panel in the process control room. This new system performs the same function as the existing system and operates in a similar manner. Some field instruments have been changed so that instead of pneumatic, electronic signals could be sent to the controller.

A new Vibration Monitoring System for Fuel Gas, Propane and MCR has been installed on the Compressors and Turbines. This system, which is located in a new cabinet in the control room, is linked to DCS vibration logging and alarm functions.

The existing steam turbine drivers for the Propane and MCR Compressors have been replaced by new turbines. New Woodward governors for the same have been also installed on the new turbines. These governors are adjustable from either the local panel or through the DCS from the control room.

A new Turbine Exhaust Steam Condenser have been installed on Trains 200 to 600 to replace the existing condensers in Fuel Gas, Propane and MCR sections.

A new Propane Transfer Pump has been installed. The main duty of this pump is to purify the propane from any heavies ($C4^{+}$).

A new Second Stage Suction Drum has been installed to replace the existing vessel in the MCR section.

One of the existing LNG pump has been removed and a new pump has been installed in its place in the Liquefaction section. Both pumps and Main Exchanger now have a double block and bleed arrangement on the suction and discharge. This will provide greatly improved isolation of the pump when maintenance work is necessary.

The existing Demethaniser Overhead Condenser has been removed and replaced by a new exchanger.

The existing Demethaniser Bottoms Cooler has been removed and replaced by a new exchanger.

The existing Demethaniser Overhead Condenser has been removed and replaced by a new shell and tube condenser.

The existing Depropaniser Overhead Condenser has been replaced by a new condenser.

The existing Ethane Returns Subcooler in the Debutaniser system has been replaced by a new subcooler.

During the renovation the following work has been carried out on the process trains steam and condensate systems.

- Installation of a replacement turbine driven boiler feed water pump and installation of minimum flow protection for both the new and the existing boiler feed water pumps.
- Installation of new analysers for pH and oxygen in the boiler feed water.
- Installation of three new phosphate dosing systems to replace the existing single system.
- Modifications to instrumentation at dearator.
- Three new desuperheaters have been installed on the process trains to replace existing desuperheaters.

The changes and additions made to this system provide more flexibility and better control without changing the overall operation of the system. Temperature and pressure set points remain unchanged although the control instrumentation has been upgraded.

Three new Closed Circuit Cooling Water Systems have been installed to replace sea water cooling system. Each system has capacity to serve two trains, the associated six existing process boilers and the new process boilers. Each system consists of a surge tank, two circulating pumps and two heat exchangers with seawater as the cooling medium.

Autoconsumption

The existing gas fired Dryer Reactivation Heater has been replaced by a new shell and tube exchanger. The heating medium for this exchanger is high pressure steam. The principle of Dryer Reactivation remains the same as the existing operation. However, the reactivation is now carried out by high pressure gas and the sequence is controlled by the DCS.

In the MCR & Feed Chilling Unit's, Scrub Tower Overhead System, a new LPG Recovery Exchanger has been installed. The scrub tower separator, reflux pumps and associated piping have been replaced with equipment and bulks fabricated from low temperature carbon steel. This has been necessary due to the new lower design temperatures. Condensation for both the lean and rich feed gas cases are now carried out in the LPG Recovery Exchanger. The existing scrub tower condenser is not required in service during normal operation; it will however be in service during plant start-up. The temperature of the condensed scrub tower overhead stream leaving the recovery exchanger is controlled by the DCS controller. The design operating temperature of this stream is -43.0 ° C for the heavy feed case and -50.3 ° C for the light feed case. The function and overall operation of the scrub tower system is similar to the operation prior to the modifications. This modification reduces drastically the start-up time of the train.

The Scrub Tower Reboiler has been replaced by two new items of equipment, a reboiler and a butane vaporiser. The vaporiser provides heating medium for the reboiler.

The scope of renovation work also needs to be specially highlighted with respect to the factors influencing the production loss, experienced in pre renovation vis à vis the post renovation period. The major reasons contributing towards the production loss, as mentioned before, were unreliability of the process Turbines and Compressors and lack of

sufficient Steam. Brief background and the scope of work pertaining to these two equipment/systems are stated hereunder.

Process Turbines and Compressors

One of the main bottleneck regarding production were the process compressors, particularly that for the Propane. An overall study and analysis were carried out and scope of work was agreed and finalised for implementation. The scope comprised mainly of the following:

- New dry coupling has been installed.
- Modification of Piping configuration around the Compressors.
- New design of the Compressor internals.

The respective Turbines were replaced with new General Electric make of higher rating. This combined modification in the process compressors and turbines enabled enhanced performance of the liquefaction trains to achieve 110% of the Contractual Installed Capacity.

Steam Generation

The steam generating capacity has been increased to improve reliability. A detailed study was carried out to ascertain the type of configuration of New Process Boilers and its numbers and extent of renovation of existing Process Boilers to achieve the requisite quantum of steam production for 109% capacity increase. The result of the study which were subsequently implemented are as follows:

- Four (4) New Boilers of 400 tph.
- Renovation of seventeen (17) existing Process Boilers

The aforesaid configuration enabled to achieve a steam reliability of 99.5% and an Installed to Requirement ratio (I/R) of 1.39.

Installed Quantities of Bulk Material

Quantity workloads of renovation work for the bulk materials as executed as per the work scope delineated in the foregoing are presented in Table 6.

Table 6 Bulk Material Quantity Under Renovation Scope

DESCRIPTION	UNIT	QUANTITY
PIPES	LINEAR METRE	135,079
ELECTRICAL		
• CABLES - RIPOUT	LINEAR METRE	104,614
• CABLES - INSTALLATIONS	LINEAR METRE	405,069
• TERMINATIONS	NUMBER	69,744
INSTRUMENTATION		
• INSTRUMENTS	NUMBER	35,000
• CABLES	LINEAR METRE	859,897
• TERMINATIONS	NUMBER	148,056
INSULATION		
• PIPES	LINEAR METRE	35,925
• VALVES/FLANGES	NUMBER	8,481
• EQUIPMENT	SQUARE METRE	5,169
CONCRETE	CUBIC METRE	20,000

V) EXECUTION METHODOLOGY

The renovation of GL.1Z project was accomplished in three (3) phases (Phases - II and III were subsequently decided to be carried out simultaneously as per Phase - I detailed audit report), as delineated hereunder:

Phase - I

The first phase comprised a detailed techno-commercial audit of the installations as stated below:

A. Review of the Complex documentation (design documents, production documents, etc.)

B. Audit of technical documentation and operating reports of the Complex.

C. Performance of functional tests on the liquefaction units of the Complex in order to identify bottlenecks and extra capacity available.

D. Review of the procedures and management systems of the Complex.

The object of this initial phase was to firm up an action plan to zero-in on the following:

A. Re-establishment of the nominal production capacity of each LNG production unit.

B. Re-establishment of the Nominal LNG Production Capacity over a period of 330 days per annum.

C. Identification of bottlenecks and proposal of solution in order to augment production capacity to a higher level than the Nominal Production Capacity.

D. To Establish the initial budget and time schedule to carryout renovation during Phases - II and III.

Phases - II and III

This combined phase consisted of implementing the results/inferences of Phase - I report in order to re-establish the CIC of the liquefaction unit and the Complex. Additionally, adequate capacities of the utilities like steam, de-min water, instrument air, etc., were installed to meet the requirements of extra LNG production capacity of the Complex.

Modifications/alterations were also carried out based on the capacity already available at the level of critical equipment (e.g., Main Cryogenic Exchangers and Refrigeration Compressors) to augment the production capacity of the liquefaction units of the Complex to an optimum level, higher than the CIC. This phase has been covered under the following major activities:

i. Project Management Services

ii. Detailed Engineering

iii. Procurement, Inspection/Expediting and Transportation

iv. Construction

v. Start-up and Commissioning

vi. Commissioning including Functional tests

vii. Performance test

The renovation work of the complex was undertaken on Cost Reimbursable and Fixed Fee basis and the contract was signed on 10 April 1990. Phase - I work was completed in June 1991 and the implementation phase started from September 1991 and was commissioned on 5 May 1997.

Sonatrach mobilised a team to Entrepreneur’s Home Office in London, consisting of specialist from various disciplines to monitor the activities of the Entrepreneur and to expedite the approval process.

Sonatrach also undertook some renovation work on their own, simultaneously with Phase - II and III of the project renovation construction activities. Procurement portion of those works were accomplished with the help of Entrepreneur’s services and the

installation part was executed partly by Sonatrach and partly with the help of the ongoing existing Phase - II and III renovation manpower and resources.

Main construction activities were executed by engaging Expatriate sub-contractors. In addition to the foregoing, labour force from Third Country Nationals were engaged in order to strengthen the sub-contractors, mainly the locals. Local sub-contractors were engaged for Pipe fabrication, rip-out and installation, civil works, Electrical & Instrumentation installations, Insulation, craneage, scaffoldings, etc.

VI) SCHEDULING AND CONSTRUCTION EXECUTION PLAN

Scheduling

The scheduling for the renovation of GL.1Z Complex was faced with constrained at both the ends, e.g., initially, completion of engineering and procurement process so that the materials and drawings are available for the shutdowns and finally the projected quantum of work and manpower restraints required for execution of the works in a safe and effective manner.

As per requirement of Sonatrach four process trains were always in production at any point of time during the renovation program, except for a limited duration of Complex shutdown. This ensured in maintaining current level of production throughout the time frame of plant renovation works. The consequence of such requirement was that a maximum of only two trains were available for work and thus increased the duration of revamping activities.

Construction Execution Plan

In order to facilitate control and management of the renovation work, the Scope of Work was packaged into the following.

1. Preshutdown
2. New Construction Work
3. Renovation & Replacement Work
4. Shutdown Work (Trains and Complex Shutdown)

Preshutdown. Preshutdown work was performed “on the run” by the renovation workforce. A typical work scope consisted of the following:

- Fire Water System: Main header and Pumps
- LNG Tanks: Anchor Bolts, Foundations, Nitrogen purge, General Civil works
- LNG Pump Pit: Civil works
- Jetty: Loading Arms; Valves
- Buildings: New buildings or extensions
- Civil Repairs: Refurbish concrete and structural steel

- Electrical: Renovation of Switchgear; installation of additional switchgear in the main substation; new cable trenches; cable pulling
- Instrumentation: Renovation and enhancement in the Offsites and Utility systems
- Acoustic protection
- Drier Area: Civil works

New Construction Work. This was considered as far as possible "Grass Roots" construction and administered as a subcontract and executed in accordance with an Area Permit arrangement where appropriate. Typical scope under this category were as follows:

- Electrochlorination
- New Boilers
- Gasoline Storage
- API Waste Separator
- Sewage Treatment Plant

Renovation & Replacement Work. This kind of work performed while the plant was in operation. These works were carried out by small teams of subcontractors under supervision of the Entrepreneur. Typical scope under this category were as follows:

- Existing Boilers
- Demineralisation Plant
- Desalination Plant
- Conversion of Gasoline Storage

Shutdown Work (Complex and Trains Shutdown). As per previously agreed project schedule between Sonatrach and the Entrepreneur, the former proceeded to Shutdown and isolate the Complex sub-assemblies and / or equipment and performed preparatory tasks (e.g. gas freeing, cleaning, washing, etc.) of the equipment and / or systems to be worked on. The Project underwent three Complex Shutdowns (CSD), namely CSD-I, CSD-II and CSD-III in addition to individual Trains shutdown for regular renovation works. Typical scope under the category of each Complex Shutdowns are as follows:

a) CSD-I
   i) Overall scope : predominantly Pipe Tie-ins to existing systems
   ii) Train 100, 200 Main Steam Header replacement.

b) CSD-II
   i) LNG / Fuel Gas transport, storage and export system (New LNG pump pit)
   ii) Flare Tips / Main Header replacement of Hot, Cold and Process Flare Gas Systems

iii) Trains 300, 400, 500, 600 and Utility 62 bar Main Steam Header replacements
iv) Utility Steam Turbine driven Boiler Feed Water Pumps
v) Synchronisation Power Service Supply for the Main Steam Turbine Generator Nos. 1, 2 & 3

c) CSD-III
i) Replacement of Main Header Steam Valves (22 nos.)

d) Trains Shutdown
i) Rip-out and installation of piping
ii) Rip-out, overhaul and installation of all Compressors and Fuel Gas Turbines
iii) Rip-out and installation of New Turbines (C3 and MCR II and III)
iv) Instrumentation rip-out and installation works
v) Rip-out and installation of new surface condensers

VII) PROJECT CONSTRAINTS

Renovation of GL.1Z Complex experienced several constraints from ab-initio and during the course of its construction / commissioning period. The major constraints are highlighted hereinafter:

Financing

Availability of finance was a major constraint during the various stages of the project. The delayed financing affected not only the forward release of critical activities required to maintain the project schedule, but also the finalisation of project scope and budget.

Scope Changes

During the audit phase (Phase - I) of the renovation program, an agreed work scope was finalised and based on which the implementation phase was initiated. However, during the course of time of implementation, substantial scope revisions/changes were made which posed challenging efforts to control schedule and cost of renovation program.

VIII) PROJECT COST

Project cost of GL.1Z Renovation Project was initially firmed up based on the work scope decided in Phase - I (Audit Phase) of the project. This initial project cost was revised by adding cost trend towards 110% capacity increase and was approved as the Initial Budget for the renovation project in August 1991. Subsequently during the construction/implementation phase of the project (Phase - II & III), seven project cost forecasts were made and the final project budget was approved in July 1996. Table 7 below shows the percentage breakdown of total project budgets. As per the final project cost the nature of revamping indicates that only Renovation was in the ratio of 43% for Trains and Offsites. Balance i.e. 54% comprised of New, New replacements and Modifications. However, in Trains, Modification percentage was higher than the Offsites by 21%, while New & New replacement was higher in Offsites by 21%, when compared with that of the Trains. In this regard it is worthwhile to note that Offsites overtook Trains

because of Four (4) new Boilers and newly replaced LNG Loading Arms (costing about 10% of the total project cost), which were a part of the Offsites. Table 8 represents the ratio/percentages in details.

Table 7 % Breakdown of Approved Project Budgets

BUDGET	DIRECT COST	INDIRECT COST	ASSOCIATED COST	CHANGE ORDERS	PHASE - I
INITIAL	47%	10%	42%	0%	1%
FINAL	58%	18%	22%	1%	1%

Table 8 % Cost Breakdown of Nature of Revamping

DESCRIPTION	TR-100	TR-200	TR-300	TR-400	TR-500	TR-600	OFFSITE
MODIFICATIONS	32%	31%	31%	31%	31%	31%	10%
NEW & NEW REPLACEMENTS	25%	26%	26%	26%	26%	26%	47%
RENOVATED	43%	43%	43%	43%	43%	43%	43%

IX) POST RENOVATION PLANT PERFORMANCE

Performance Tests after the renovation works were carried out as per the following:

* Train 100 : From 25 May to 28 May 1997 for 72 consecutive hours.
* Train 500 : From 29 September to 02 October 1997 for 72 consecutive hours.

The Plant performance test results were found to be satisfactory.

Important Plant Performance results are given below.

- Individual Train production performance : From 100% to 120% as against pre-renovation magnitude of 85%
- Plant Overall Production performance : 105% from May 1997 as against pre-renovation value of 60%
- Trains Start-Up duration : 8 hrs. as opposed to 24 hrs during pre-renovation operating years
- Plant Start-Up duration : 3 days instead of 10 days prior to renovation
- Autoconsumption Ratio : 15% instead of pre-renovation value of 20%
- Reduction in number of trips and frequency of accidental maintenance.

Reliability Test period for the renovated GL.1Z Complex commenced from 1 December 1997 and would continue for 365 days, after which Final Acceptance would be effected.

X) CONCLUSION

As discussed earlier, renovation of GL.1Z LNG Complex was necessitated since the grass root Plant commissioned in February 1978, never achieved its design production capacity. It was a major concern for Sonatrach as LNG production and its export controlled a large part of Algeria's economic situation and its credibility in the World LNG trading. With the aim of simultaneous improvement in Algeria's economic condition, to meet the customer's demand and further augment Algeria's contribution in the competitive World LNG Trading, Sonatrach initiated and successfully completed renovation of GL.1Z Liquefied Natural Gas Complex with all six trains in operation with effect from 5 May 1997.

Renovation works was a challenging and ambitious task since during the whole tenure of revamping works the Complex was always in partial production (minimum four trains out of total six trains) to meet the customer's demand. Moreover things became more complicated during the course of renovation works due to persistent financial constraints, lesser contribution and availability of Local manpower and resources and worse ever security situation in Algeria. In spite of such ever increasing stumbling blocks and constraints which were not envisaged during inception of the renovation program, Sonatrach overcame everything due to sheer perseverance, fast learning and singular dedication. As it stands today, Sonatrach GL.1Z Complex operating in full renovated capacity, is striving for the best possible maintenance and operation of the plant through meticulous planning and implementation of training programmes and research and development activities.