FILE N. 20

UNDERGROUND COAL GASIFICATION FIRST TRIAL IN THE FRAMEWORK OF A COMMUNITY COLLABORATION

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TECHNICAL REPORT JANUARY 1997 - JUNE 1997

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SUMMARY

The major activities during the period have been the completion of plant commissioning, the development of process procedures, completion of outstanding modifications to ignition CRIP system, and the satisfactory acquisition of the authorisation and certification of the plant.

Gasification operations began at the end of the period (June 97) and good communication has been established between the injection and recovery wells.

An important activity has been the training of UGE staff in the operating and safety procedures for the plant. A new Director was appointed on 1st April and the internal management structure has been overhauled in preparation for gasification operations. The operating procedures of the plant have been established during the training and commissioning stages, the staff is well trained and the plant is ready for ignition, which is expected to take place in the next few weeks.

1. INTRODUCTION

The report describes a period of intense activity to prepare the plant and the staff for gasification operations.

A number of essential modifications had previously been identified and the first months of the period were required to assemble new components and install them on site. The co-ordination for the redesign, procurement, commissioning and installation of the new coiled tubing required visits to France and Switzerland, and fatigue tests were performed in the USA

Commissioning of the plant followed, and experience had to be gained quickly in the integration of the individual package units into a fully operating and safe system. The conversion of the UGE staff of engineers from design and construction work to safety conscious plant operations, including supervision of experienced support technicians, was an important milestone.

In parallel, the underground processes were re-examined, CRIP ignition points confirmed and a detailed process manual was developed and reviewed by external advisors.

The preparation work, commissioning and certification of the plant was finally completed in mid June and the report describes the initial results that have been obtained in the pre-gasification stages of operations.

2. SURFACE PLANT

2.1 COILED TUBING

The problems previously encountered during insertion of the coil tubing in the injection well have been studied by UGE engineers and the tubing manufacturer DOWELL SCHLUMBERGER. A major revision was initiated and the new design was submitted for manufacture after DOWELL SCHLUMBERGER admitted their responsibility and offered to solve the situation at no cost to UGE.

The new Coiled Tubing tube was manufactured by ZM in Switzerland, and intensive fatigue testing (Appendix 1) were undertaken by Precision Tube Technology of Houston, Texas, to properly qualify the new tubing manufacturing quality.

The results were very positive. At the same time several adaptations were made to the unit to improve safety in presence of O2 and general reliability.

The explanation for the November mis-run is still unknown. As a result, a series of tests were performed in Pau, France, to confirm the behaviour of the control lines inside the new coiled tubing as the assembly is run into the injection well. At the same time the complete assembly, testing, certification and cleaning procedures were adapted to simplify insertion and improve the safety handling during gasification.

The installation of the new injection assembly in the injection well IW1 was completed successfully on 8th May 1997, and connection to the well head were also achieved and tested without further problems.

It was further decided to recondition some of 1.66" tubings from the first injection assembly as a back up.

2.2 OUTSTANDING PLANT MODIFICATIONS

a) Combustor

The conversion of the combustor to burn gas of any quality involved the installation of a new propane injector and associated controls. The main components were installed in February 1997 when the basic safety control changes were completed and tested. However, the computer required to calculate propane injection rates as a function of product gas quality and flow rate has been a continuing problem, due, we believe, to the lack of experience in computer control by the installer.

There have been subsequent additional failures of the control system and the installing company has also had serious financial difficulties. The result is that the combustor control remains suspect and alternative solutions are being sought using other companies to resolve the difficulties. The combustor is a critical unit for the ignition phase of the gasification programme, and considerable effort is being applied to solve the outstanding problems.

b) Recovery well Suspension System

The suspension system for the production lines close to the recovery well has been installed successfully to allow the well head possible thermal expansion maximum of 100 mm. The lines are now literally floating, even though their exact weight was unknown, and approximation were given for dimensioning calculation. The three Tee connections identified as the weakest points of the lines were also reinforced. Insulation of the suspended pipework and recovery well has also been replaced.

2.3 GAS ANALYSIS AND INSTRUMENTATION

a) On line Instrumentation

A contract was placed to provide two instrument technicians working in shifts to cover:

a) the on-line instrumentation for the main gas components

b) the operation of the mass spectrometer for detailed on-line gas and vapour analysis

c) the satisfactory performance of the sampling system for gas, liquid and solid products

d) the collection, in conjunction with UGE engineers, of the daily samples.

b) Batch Sampling

An analytical laboratory has been commissioned to transport and analyse the product compositions in the three phases, solid, liquid and gaseous, using the analysis protocol and sampling system in (Appendix 2).

The combination of on-line instrumentation and batch analysis are critical to the determination of mass balances and are the principal reasons by which the underground operations can be monitored. The control system has been programmed to calculate mass balances on line.

In addition, a back up system for oxygen detection has been installed close to the recovery well to monitor oxygen levels in the production gases. This is an additional safety measure which would be used to shut down the oxygen supply in the unlikely event of an oxygen bypass into the production lines.

2.4 PLANT COMMISSIONING

Commissioning which has been thorough and intensive has taken about 5 months to complete and the process has revealed a number of design and installation faults. The most common were leaks in the supply line, significant failures of the micro turbine flow measurement devices and the discovery that many of the inlet tubes and sample lines needed extensive cleaning.

The most serious problem however has been the cryogenic pumps attached to the liquid oxygen and nitrogen units. These have been prone to cavitation and leaks and the supplier has attended the failure without, so far, an entirely satisfactory solution.

On the other hand, the on-line instrumentation and mass spectrometer has been commissioned without difficulty, the steam supply system is working well and the coiled tubing assembly and insertion structure has performed satisfactorily. Some final modifications are underway to the gas sampling system to ensure that complete condensation of liquids takes place prior to on-line analysis.

The Honeywell computer connected to the control system, records all variables from the plant, from the data analysis cabin and the accumulated fibre optic temperatures measurements. These results are then averaged over one hour for the daily reports that are sent to UGE Members. Tape back up is provided for the data on a weekly basis. The operator screens carry process schematics of all the plant stages with instantaneous read out and automatic control of the key pressure flow and temperature variables.

A series of tests have been undertaken in the low and high flow production lines using a simulated production gas of nitrogen and water vapour. The tests established that water can condensate in the horizontal sections and that the maintenance of pressure at around 5 bar in the medium pressure section required significant operating skill. The control loops were subsequently retained to achieve more accurate automatic control and the problem has been overcome.

Construction of IW1 $9^{5/8}$ and 7" annulars decompression lines to combustor (Phase 10-11) has been completed.

The commissioning program was completed by week 26 (23rd June), ready for the start of operation during the following week.

2.5 Safety installation

Plant safety has been a primary concern throughout the commissioning period. Measures which have been undertaken include:

- complete upgrade of the fire fighting system
- oxygen line qualification to confirm cleaning and degreasing were effective
- emergency lighting
- first aid refresher and personal protection equipment distributed.

A later addition was the installation of two lighting rods, which were to be required because the plant is located in a high risk area. Fortunately the protection was in place when lighting struck the plant a few weeks later.

An external consultant has provided a full safety audit of the plant, a study of the safety readiness and knowledge of the staff, and the execution of a full simulated emergency involving fire and personal injury. The results confirmed that a high standard of safety preparedness had been achieved.

3. PLANT OPERATIONS & ENVIRONMENTAL MONITORING PROGRAMME

PLANT OPERATIONS

24 hour shift operation began at the end of June, and the tests to date have been focused on well tightness and water connection between the injection and recovery wells.

Water Pressure Test

The two wells were filled with water and the well heads then pressurised to 30 bar. The well heads were found to be water tight after 1 day of operation.

Water Communication Test

The objective was to check the quality of water communication between the deviated injection well and the production well under water conditions to check water loss in the formation.

It was found that at water flows up to 6.0 m^3/hr and well head pressures of typically 6-8 bar, the water recovery was in the range 65 -95%, which indicated that significant quantities of water were being lost to the formation. Figure 1.

Well Head Pressure Drop

A further result for the water connection phase is the variation in well head pressures and the resultant pressure drop relationship with flow rate (Figures 2 & 3). They indicate that water pressure drop is linear with flow rate except at very high flow rate where some extra resistance may be caused by the presence of loose materials. The appearance of the recovered water confirmed that a quantity of suspended coal particles has been flushed through the well.

The water communication phases were successfully completed and the plant and well were ready to proceed to the nitrogen water exchange phase.

Helium Tracer Test

Preliminary tests of the Helium tracer system have been made during the nitrogen lift condition in order to test the He pulse procedure and make a first cavity measurement. Figure 4. The result gives a mean residence time of 240 seconds and suggest an initial "cavity" of between 400-500 litres.

Environmental Monitoring Programme

The environmental monitoring programme is aimed at establishing a base line for ground water hydrology in the area surrounding the El Tremedal trial prior to gasification phases.

Two sets of data are collected each month. The ITGE take samples and analyse:

Alcorisa water supply
Foz Calanda water supply spring
" " " " well

and UGE sample:

Alchozasa River - 3 Points
New Tremedal Well
IW2 on site

The latter results are collected by the laboratory ENTIDAD COLABORADORA DE LA ADMINISTRACIÓN (ECA) from Zaragoza and a detailed analysis is undertaken, an example of which is given in table 1. First indications are that the water quality is within the specification for a good river water although the level of phenol is higher than the limit. This result is being further investigated.

Table 1. Analysis of UGE Water Sample for June

	Alchozas River			**New El Tremedal Well**
	Point 1	Point 2	Point 3	
Calcium (mg/l)	128	120	125	195
Magnesium (mg/l)	45	40	45	120
Sodium (mg/l)	18,6	16,2	16,4	15,0
Potasium (mg/l)	2,1	1,8	1,7	10,8
Bicarbonate (mg HCO_3/L)	278,16	272,06	274,5	45,14
Sulfates (mg/l)	218,01	219,62	213,19	1080,15
Chlorides (mg/l)	45,3	43,5	40,0	40,0
DQO (mg/l)	5,63	5,76	3,84	1,90
Total dissolved solids	701,5	772,5	719,5	1557,5
Nitrates (mg/l)	1,90	2,61	2,75	0,19
Organic carbon (mg C/l)	5	5	5	3
Phenol (mg/l)	0,01	0,09	$<$ 0,01	0,08
Bore (mg/l)	$<$ 1	$<$ 1	$<$ 1	$<$ 1
Ammonia	0,7	0,7	0,7	0,7
pH	7,952	7,872	8,108	7,140
Alkalinity TAC (meq/l)	4,56	4,46	4,50	0,74
Conductivity (µS/cm)	864	865	906	1580
CO_2 dissolved (mg O_2/l)	7,54	9,76	9,09	13,86
Benzene (µg/l)	$<$ 0,1	$<$ 0,1	$<$ 0,1	$<$ 0,1
Total petroleum hydrocarbons (mg/Kg)	$<$ 2	$<$ 2	$<$ 2	$<$ 2

4. PROCESS ANALYSIS AND MODELLING

4.1 PROCESS PHASE MANUAL

An important activity in this period has been the development of the full operational manual for the process.

The main phases of the gasification process are shown in figure 5. For each phase a detailed procedure has been prepared to cover objective description, duration, sequence of operations and the end criteria which must be met in order to proceed to the next stage. "What if" scenarios have also been constructed and analysed for each phase.

The draft manual was reviewed in a two part process, first by UGE staff and secondly in a specially convened meeting of technical advisors in Liege in April 1997.

4.2 PROCESS MODELLING

a) A mass and heat balance of the process has been developed and programmed into the on-line control system.

b) The two basic models, in which pyrolysis and the gasification reactions are described separately, have been reprogrammed using EES (engineering equation solver) software. The model is now available for interpretation of results during the gasification process.

c) Estimates have been made of the flammability of the likely mixtures using the computer program INFLAM from the University of Liège. The study concludes that no detectable oxygen must be allowed in the production lines because the lower flammability limit at temperatures above 100^{oc} is close to zero. For this reason, the back up O_2 detector gas been installed close to the recovery well, so that in the event of detectable O_2 levels in the production lines immediate alarm and action i.e. cut off O_2 supply is initiated.

4.3 GEOLOGICAL ANALYSIS

Analysis of Injection Well Trajectory and Selection of Ignition Points

A re-estimation of the trajectory has been undertaken in order to fix the possible ignition points for the CRIP. The analysis established that the maximum apparent thickness of limestone above the trajectory was 1.4 m. Figure 6, and that the scope for ignition within the seam itself was limited to approximately 10 metres in the section near the recovery well and 11 metres up to the shoe of the liner.

Earlier tests on limestone cores in an oven had revealed a two stage process in which drying is followed by CaO formation and eventual consumption of the embedded coal particles. A criteria of 0.3 m was established as the maximum distance below the coal seam at which ignition should be attempted: possible CRIP points which result from this process are marked on the diagram.

Reactor and Operational Process

The lithostatic, hydrostatic and fracture pressure for the formation, as a function of true vertical depth have been calculated in order to establish the operation pressure range for the well. The result is shown in figure 7. It is important to operate below the fracture pressure in order not to damage the structure and a provisional maximum of 20 bar below pressure has been set .

Water ingress will occur at pressures below the hydrostatic pressure and ideally, this should be balanced by well pressure to minimise the ingress of water, as far as possible. These calculated results are currently being validated and operating procedures defined with the real data for water connection.

5. SUPPORTING PROGRAMME

External technical support came mainly from an ad hoc meeting of the Advisory Group in Liege in April. Detailed comments and advise was given on the process phase manual and general views on the likely gasification conditions were discussed based on the experience of those present from la Gazeification INSTITUTION POUR LE DEVELOPPEMENT DE SOUTERRAINE (I.D.G.S.), the University of Louvain, the UK mining industry and the Spanish Engineers from UGE. Some of the topics considered were

(1) mechanics of coiled tubing: assembly and installation procedures
(2) combustivity of limestone / coal mixtures
(3) efficiency of the gasification process
(4) importance of the tracer and deuterium tests

Appendix 3 is a summary of the conclusions of the meeting.

UGE Members have provided additional support during the period. In particular INSTITUTO TECNOLÓGICO Y GEOMINERO DE ESPAÑA (ITGE) has prepared an outline environmental programme for a five year period after gasification is complete, and I.D.G.S. has provided consultancy support on site for the interpretation of results and assistance in the solution of the outstanding plant commissioning problems.

External consultants have also been used for developing the internal safety manual and undertaking a full safety audit prior to the start of gasification.

An agreement with the UGE Members on the daily report format for shift, process, plant, has been formalised and an e-mail system for the transmitting the information on a daily basis using e-mail has been tested.

6. PROJECT DIRECTION

6.1 PERSONNEL

A new Director, Dr Michael Green, formerly Technical Controller, R&D British Gas was appointed on the 1st April, to replace Dr Alan Bailey who had led the project from the start in 1991 and retired on health grounds.

Six additional technicians joined the project from the service company SIEMSA, to provide shift support during gasification operations. They undertook a two weeks safety and operational course followed by shift team training before 24 hour operations started at the end of June.

Sickness of an engineer for 6 weeks depleted the technical support team, but this loss has been compensated by the addition of three temporary staff, one chemist, one engineering student and a coal combustion expert from the Zaragoza coal institution CARBOQUIMICA.

Other supporting contractors are the two instrument technicians from DENION, the DOWELL SCHLUMBERGER engineer to operate the coil tubing and a 24 hour guard from PROSEGUR, all of which will be retained until the end of gasification.

6.2 INTERNAL MANAGEMENT

Gasification will impose on UGE, the need for a structure which is able to respond quickly to the operations conditions.

The Directors have reviewed the requirements of the gasification phase and have agreed that 24 hour operation will take place on the following phases:

- Nitrogen Injection
- Ignition, CRIP manoeuvre
- Channel Gasification
- 2nd CRIP
- Shut Down

Planned programme time for the shift operation is 16 weeks, from the receipt of final authorisation, but this could increase or decrease depending on the progress of gasification. and any mechanical failure or underground disruption of the operation. The shift process will be reviewed after 1 month of gasification.

The structure for the internal management of the gasification process is shown in figure 8.

The key features are:

1. Directors will form a group, which meets 2-3 times per week, to review progress of gasification, make decisions about future phases and provide recommendations to Council on key stages of gasification.

2. A duty Director is identified each week to whom the shift engineers report.

3. A prevention officer has been appointed to advise the Directors on safety matters.

4. A technical back office is formed to provide analysis and interpretation of results.

5. The Council are kept informed by regular, at least weekly, reports.

6. The Director Facultativo will be advised of significant operational events by both the shift staff and the Management Group.

In the event that 24 hour shift operation is suspended, either temporarily or permanently, the roles of the Directors and engineers staff will revert to normal arrangements.

6.3 TRAINING AND SAFETY

The approach of gasification operations required an extensive programme of training in the plant operation and the safety procedures which must be followed on site.

The process manual contained operating procedures for the individual plant as well as the process phases themselves. They were studied and learned by all UGE engineers and practical instruction was provided for contract technicians. A series of team building procedures were conducted for the four shifts of two engineers and two technicians. The most important were the use of simulated gas flow in the production line using nitrogen and water vapour. These required all sections of the plant (except oxygen) to be operational and provided valuable experience in operating the production line

Safety training was based on a manual which was prepared by external consultants, reviewed with UGE staff and finally agreed with mine authorities of DGA (Diputación General de Aragón).

The topics covered include basic safety procedures, personal protection, rules for on site work, plant access and the emergency plan. All staff have had extensive training in the safety procedures.

In addition, an external consultant has provided a full safety audit of the plant, a study of the safety readiness and knowledge of the staff, and the execution of a full simulated emergency involving fire and personal injury. The results confirmed that a high standard of safety preparedness had been achieved.

Finally, a safety committee has been formed to oversee all safety related activities and provide a channel for communication and staff awareness. One of the first tasks was to investigate an incident in which a technician received minor eye injury while disconnecting a flange containing well water. Full eye protection and an improvement and clarification of the role of shift team members were the main lessons learnt.

6.4 AUTHORISATIONS / LEGISLATION

The final stages of authorisation to obtain the operating licence for the plant proved to be a lengthy process.

Contractual difficulties with the design and construction company (SERELAND) led to an application by UGE to the regulatory body for engineers to change the 'Director de Obra' (the person licensed to issue plant safety certificates). This resulted in a delay of 2 - 3 months.

Comprehensive documentation and 12 certificates had to be completed to cover the industrial plant units and their commissioning. Three site visits were made by different regulatory bodies.

A major difficulty was the need to obtain comprehensive insurance cover for the production of toxic residues which could possibly be carried from the well to the surface at the end of the gasification process.

Eventually, cover was obtained for both accidental spillage of the toxic materials and for gradual pollution (i.e. where the cause is less obvious). The insurance cover for the late will operate for five years beyond the end of the trial.

An important additional document for operations is the internal safety disposition, which was formally submitted on behalf of UGE by ENDESA. The Director Facualtativo from ENDESA has the responsibility towards the authorities for safety matters and has to be kept fully informed of all safety issues relating to the plant including any incidents.

The certification to operate the plant was finally obtained on the 24th June in time for operations to begin the following week.

6.5 CHANGES IN TECHNICAL STRATEGY

The previous report drew attention to the UGE Council decision based on further analysis of the site geology, that preparation for the filtration gasification should be suspended at that time. As gasification is now imminent it seems prudent to revise the decision once results for the channel stage are available and in the meantime the second filtration well is maintained in good condition.

6.6 FUTURE WORK

The immediate task ahead is to proceed through the gasification process and a schedule is given in Figure 9. It is anticipated that the maintenance of plant units and possible unit modifications will occupy most of the engineering effort.

A technical support team has been built to provide engineering support to the gasification phases, maintain supplies and undertake on-line interpretation of results.

Attention is also being given to the immediate post gasification activities which include a satisfactory and complete shut down of the process and an initial corrosion investigation of the recovery and inlet well components. Analysis of results and the production of a preliminary report is also a high priority.

In addition to the data analysis, Modelling, Interpretation by UGE Engineers, possible contracts are anticipated with I.D.G.S., DELFT, LIEGE Universities and CARBOQUÍMICA for modelling support of the gasification process. Additional underground geological evaluation may also be required to investigate the cavity.

Once the required down-hole equipment has been recovered, the lower part of each well has to be sealed. The cavity created by the gasification is filled with water, but is in direct communication with surface and is very corrosive. The Injection and Recovery Wells casing being mild steel, will be corroded away rapidly. Sub-surface strata contamination with toxic contaminants needs to be carefully monitored.

The current water monitoring program is aimed at monitoring existing water conditions of remote water wells, where the risk of contamination is very low.

A monitoring program, over the same period, but much closer to the gasifier will be considered in order to understand clearly the evolution of water migration after gasification and shutdown. Water sampling from the existing well during the next 5 years would provide the closest sampling point to the gasifier area.

The package units have to be dismantled, some could be coooned and stored for further application, some can be sold. All the piping work should be dismantled and very likely scrapped. The dismantling of the units can be done very rapidly.

Decisions then must be taken in association with Alcorisa Council on the restoration of the site and any construction that could be left in place (water pools, fences, road, ...). All these activities could be entirely sub-contracted and the greening stage can be performed while the water monitoring program is going on.

A patent search and review has also been initiated.

6.7 EUROPEAN WORKING GROUP

The start of the contract already agreed under THERMIE B "for dissemination of results of the existing project and formulate a future programme" has been postponed until meaningful results have been obtained under the current trial. It is planned therefore to call a preliminary meeting of the working group in September / October, to which european organisations expressing an interest in future underground gasification programmes will be invited. At present, this includes the existing UGE Members from Spain, U.K. and Belgium together with NOVEM and Gaz de France.

6.8 CONFERENCES, PUBLICATIONS, REPORTS

Internal Reports

Coiled Tubing - Meeting Dowell Schlumberger - UGE, Alcorisa Jan 97 (150/IN/97/E)
Internal Report Prepared by A. Herrer

Coiled Tubing - Operations for Recovery of Control Lines and Weld Samples
Pau, Jan. 97 (151/IN/97/E)
Internal Report Prepared by A. Herrer

Coiled Tubing Assembly Procedure - WELL IW1 (152/IN/97/E)
Internal Report prepared by A. Herrer.

Coiled Tubing - Meeting Dowell Schlumberger - UGE, Pau Feb. 97 (153IN/97/E)
Internal Report Prepared by A. Herrer

Pressure Test - Technical Proposal Report (155/IN/97/E)
Internal Report Prepared by J.L. Conchello

Low Pressure Test Report (156/IN/97/E)
Internal Report Prepared by J.L. Conchello

Pressure Test - Technical Proposal Report (157/IN/97/E)
Internal Report Prepared by J.L. Conchello

Spot Oxygen Samples from IW-1 (158/IN/97/E)
Internal Report Prepared by J. Carrasco

Equipos Protección Personal (159/IN/97/E)
Internal Report Prepared by J.L. Arranz

Prácticas Extinción Incendios (160/IN/97/E)
Internal Report Prepared by J.L. Arranz

Permisos / Autorizaciones Equipos - Lista (161/IN/97/E)
Internal Report Prepared by E. Comín

New Line to Decompress the Reactor - Proposal (162/IN/97/E)
Internal Report Prepared by J L Conchello

Tabulación Ofertas Analizador de Oxígeno (165/IN/97/E)
Internal Report Prepared by J. Carrasco

Legalizaciones de Equipos. Reunión DGA-UGE (166/IN/97/E)
Internal Report Prepared by J.L. Conchello

Minutes - Meeting I.D.G.S.- UGE, Liege Apr. 97 (167/IN/97/E)
Internal Report Prepared by J.L. Arranz

Manual de Operaciones - Detector Múltiple de Gases (169/IN/97/E)
Internal Report Prepared by C. Barat

Safety Report - Coiled Tubing Insertion Operations (170/IN/97/E)
Internal Report Prepared by A. Herrer

Oxygen Lines Manipulation (172/IN/97/E)
Internal Report Prepared by J.L. Conchello

Manual de Seguridad (175/IN/97/E)
Internal Report Prepared by F. Adrian

Production Line Supports (177/IN/97/E)
Internal Report Prepared by J.L. Conchello

Normativa para el Uso de Material de Seguridad (178/IN/97/E)
Internal Report Prepared by J.L. Conchello

Operations Manual - Short Version (179/IN/97/E)
Internal Report Prepared by A. Herrer /J.L. Arranz

Operations Manual - Full Version (180/IN/97/E)
Internal Report Prepared by A. Herrer / J.L. Arranz

Protocolo de Toma de Muestras (181/IN/97/E)
Internal Report Prepared by J.L. Arranz

Reports by External Organisation

Desengrasado Preoperacional de Pozos
(UGE ref. 86/22.01.97)
Report prepared by SOLARCA

Limpieza Química Preoperacional Tuberías Acero al Carbono Inoxidable
(UGE ref. 87/22.01.97)
Report prepared by SOLARCA

Inspección Válvulas
(UGE ref. 88/06.02.97)
Report prepared by SOLARCA

Régimen de Organización Interna y de Organización de UGE
(UGE ref. 89/21.04.97)
Report prepared by Uría & Menéndez

Desengrasado Preoperacional del Pozo RW
(UGE ref. 91/25.04.97)

Report prepared by SOLARCA

Informe sobre Análisis de Aguas
(UGE ref. 93/25.04.97)
Report Prepared by ECA

Disposiciones Internas de Seguridad
(UGE ref. 94/29.05.97)
Report Preparaed by D Luis Constante

Estudio Instalaciones de Soportes
(UGE ref. 97/25.04.97)
Report Prepared by por METALCAÑIZ

Site Installation of Prima 600
(UGE ref. 98/25.04.97)
Report Prepared by VG GAS

External Publications

"Drilling Well Completion and Engineering Activities in preparation of the First Underground Coal Gasification Trial in the Framework of a European Community Collaboration, Alcorisa, Spain"

F. Fievez[a], A. Goode[b], M. Green[a], J-M González Lago[c], M. Mostade[d] and A. Obis[a]

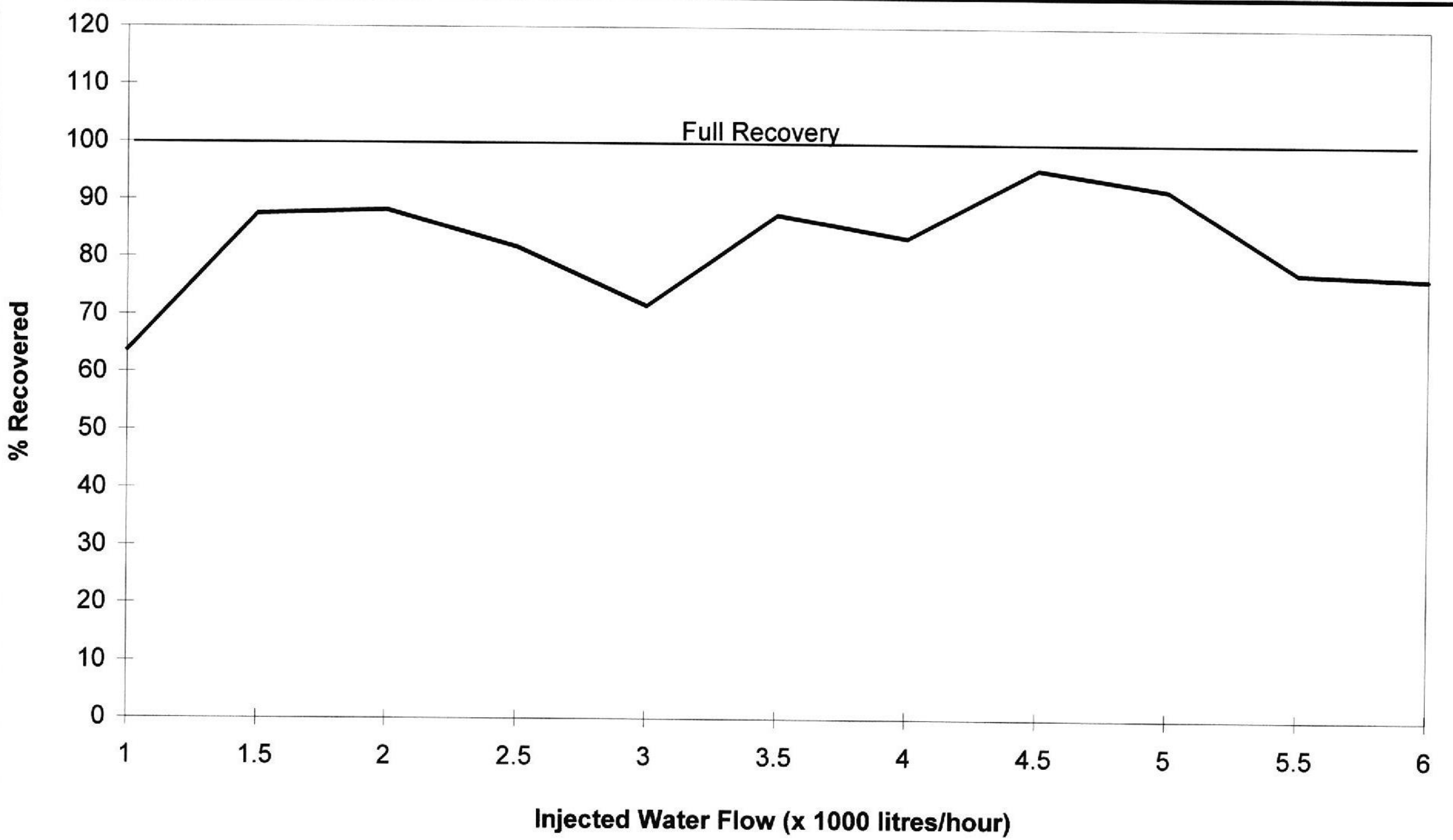

Figure 1. Water Comunication Test. % Recovery of Injected flow at Recovery Well

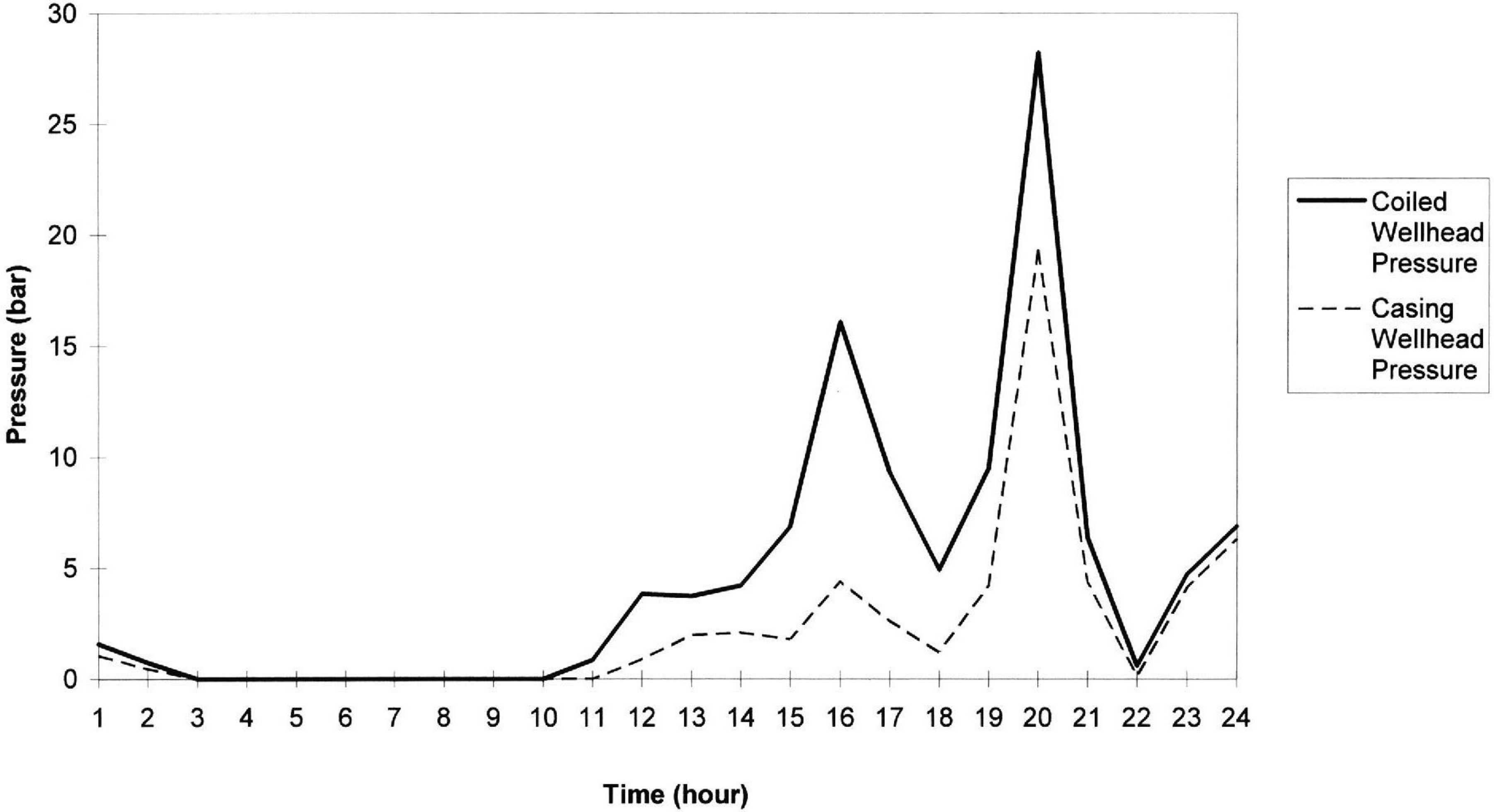

Figure 2. Water Comunication Test: Inlet and Recovery Pressure versus Time. Day 01-July-1997

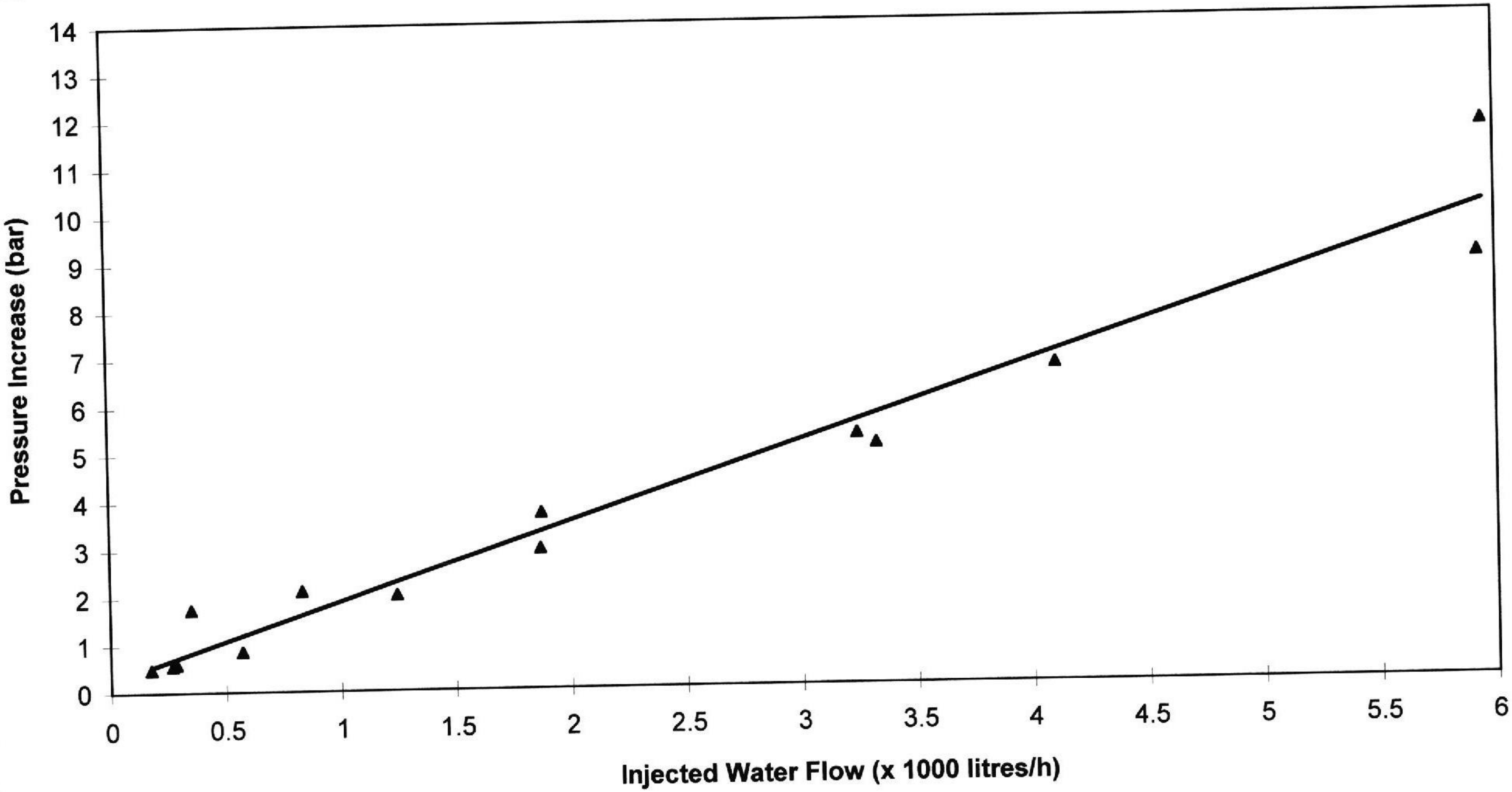

Figure 3. Water Comunication Test: Pressure Drop versus Flow Water   Day 01-July-1997

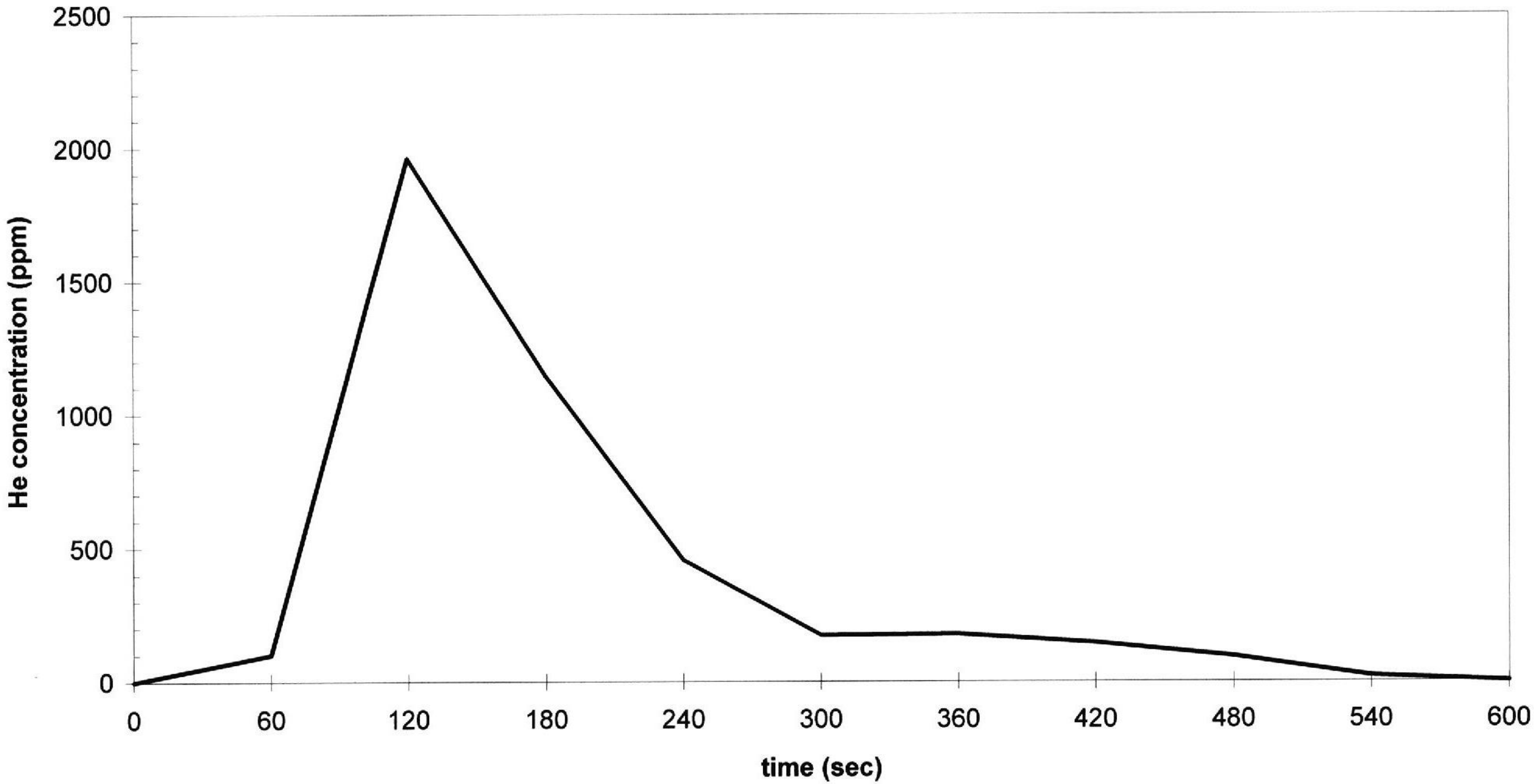

Figure 4. Helium Tracer Test nº 4. Day 05/07/97 Hour 10:21

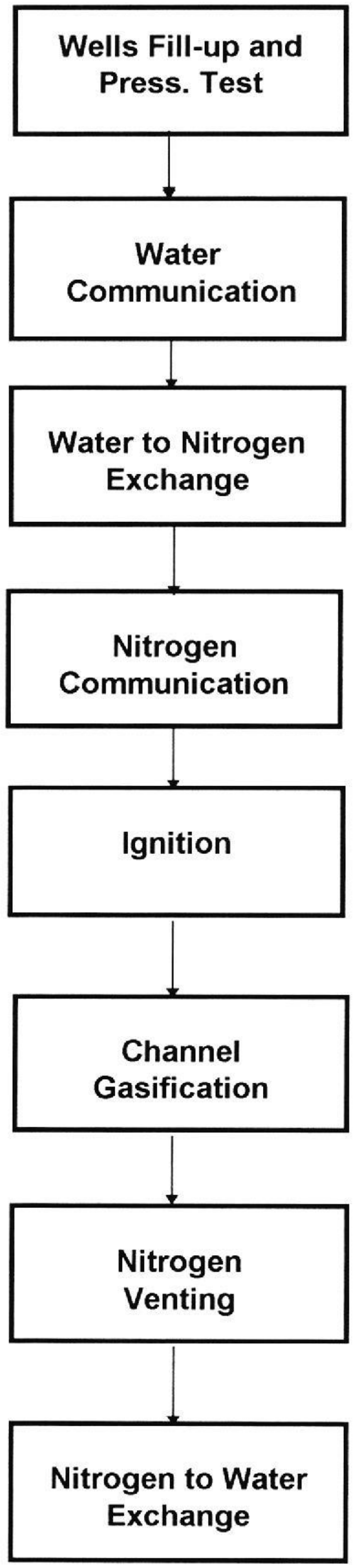

Figure 5. U.C.G. Sequence

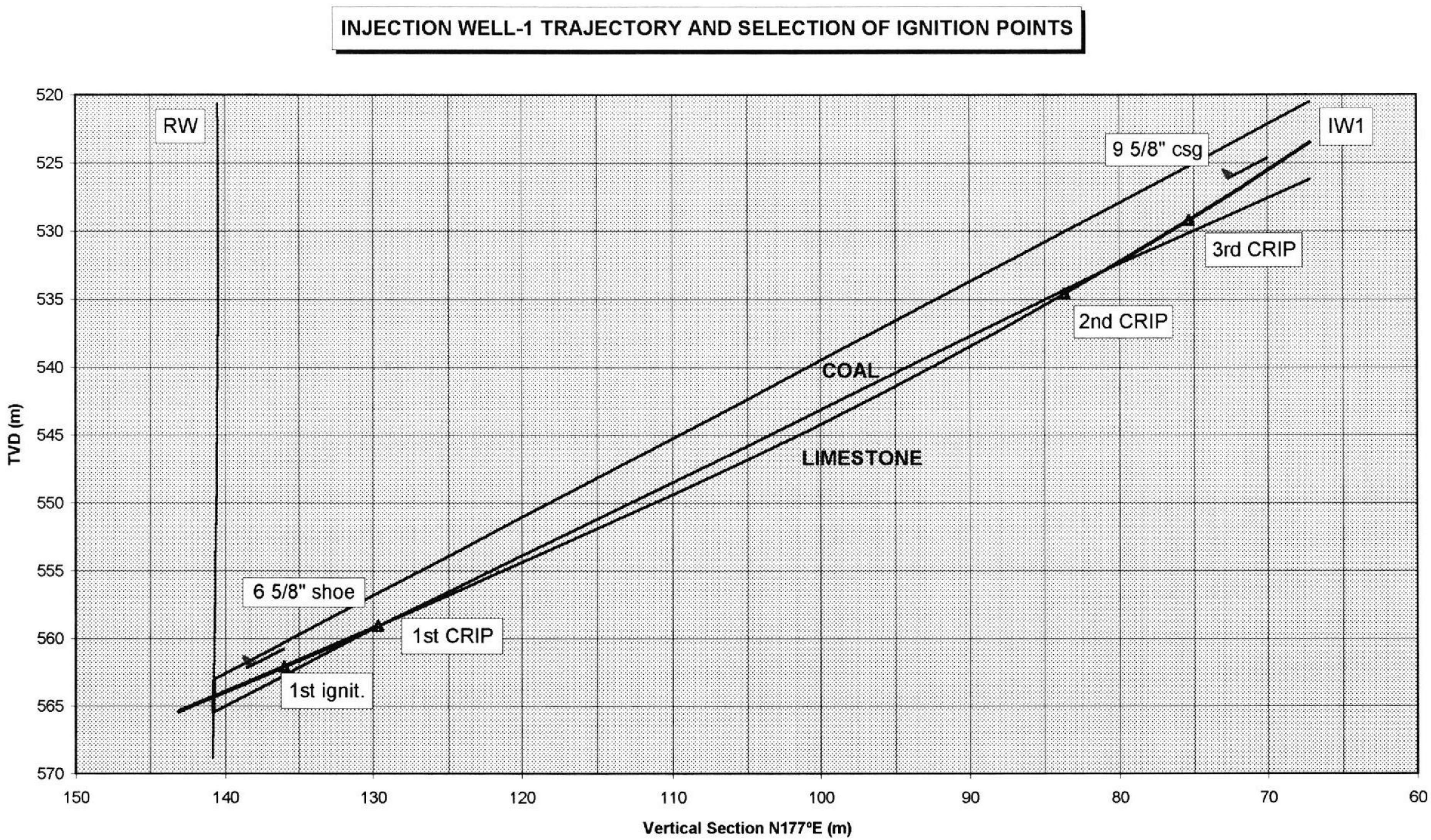

Figure 6. Injection Well - 1 Trajectory and selection of ignition points

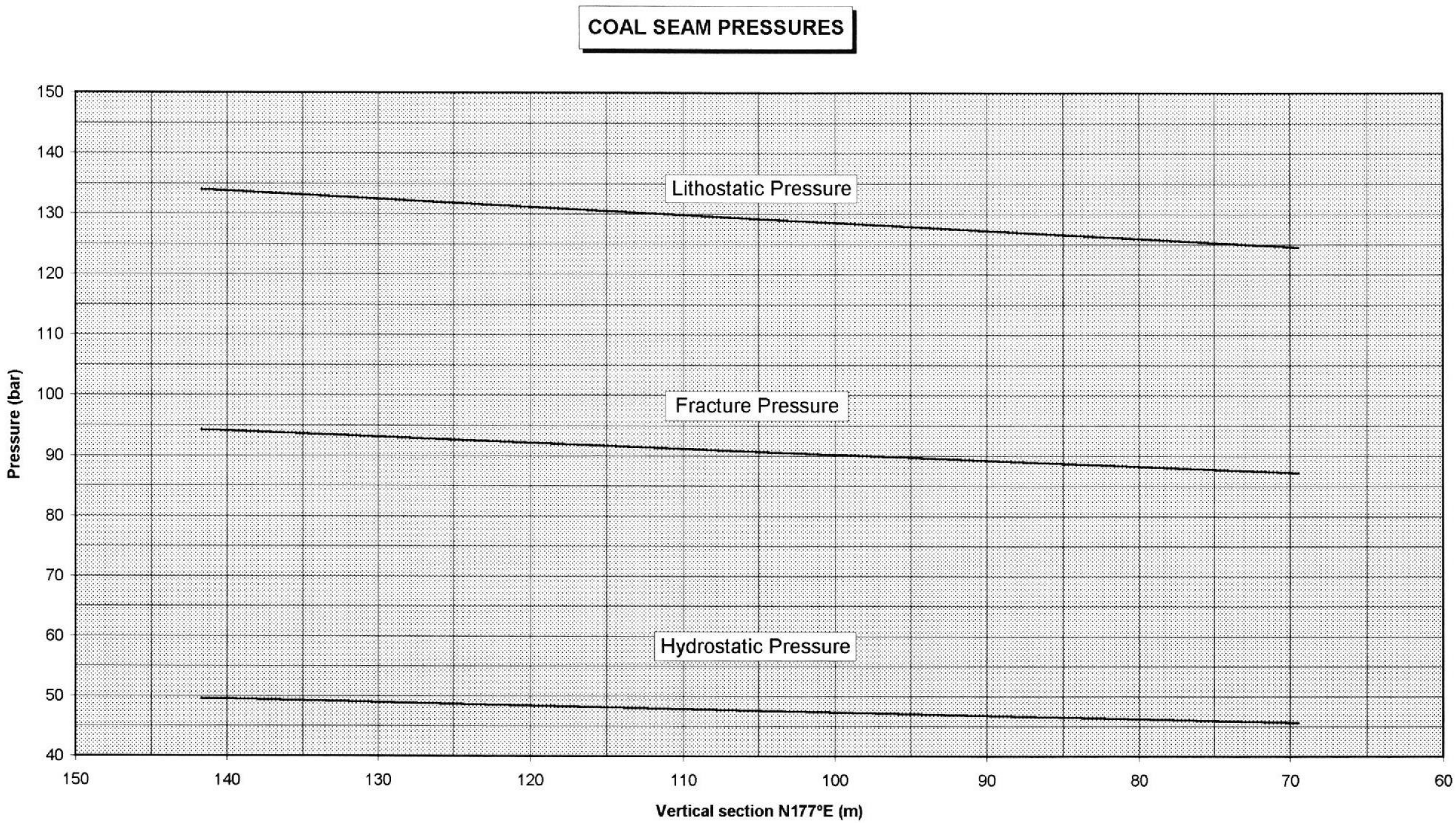

Figure 7. Coal Seam Pressures

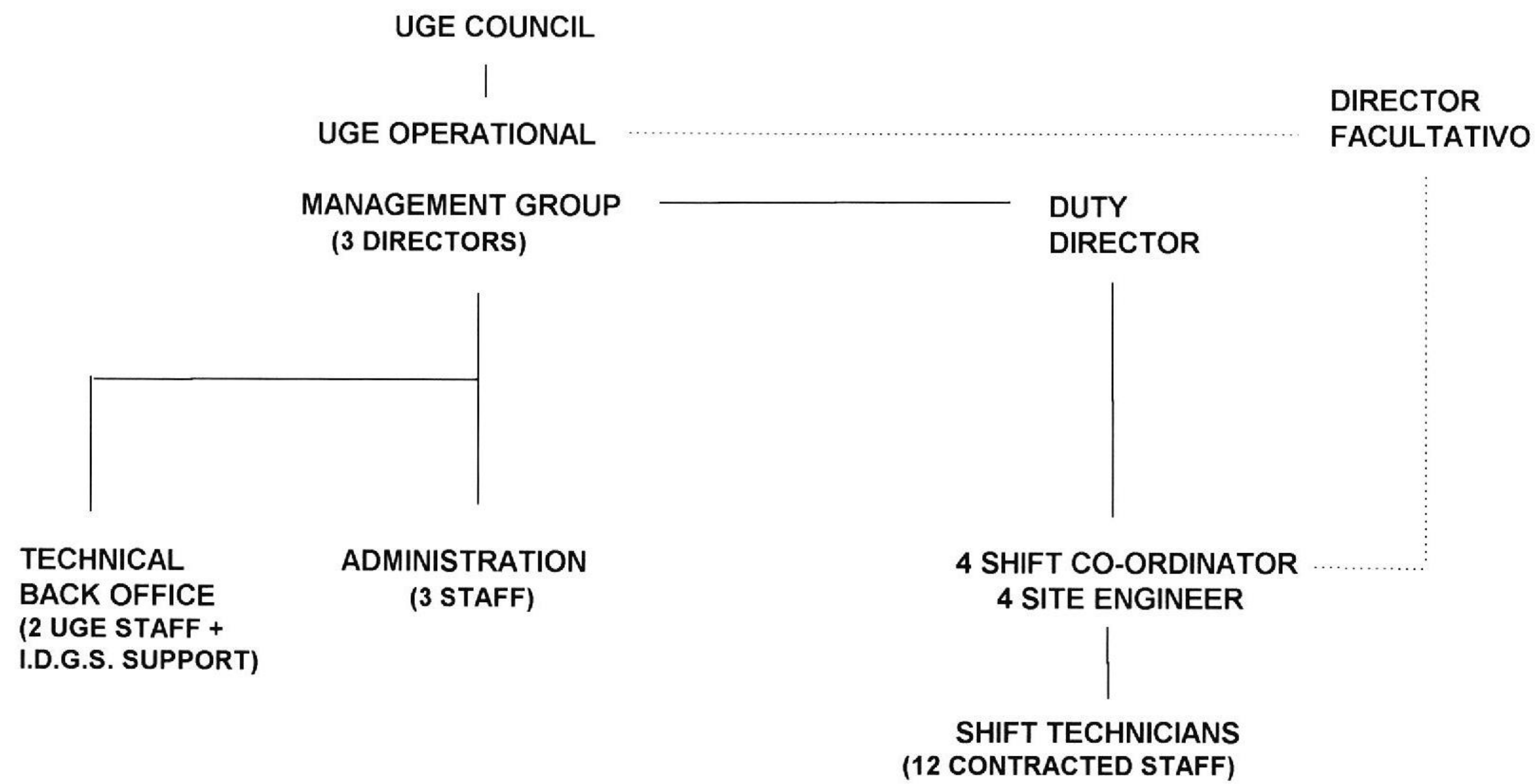

Figure 8. Reporting Structure during 24 hours Shift Operation

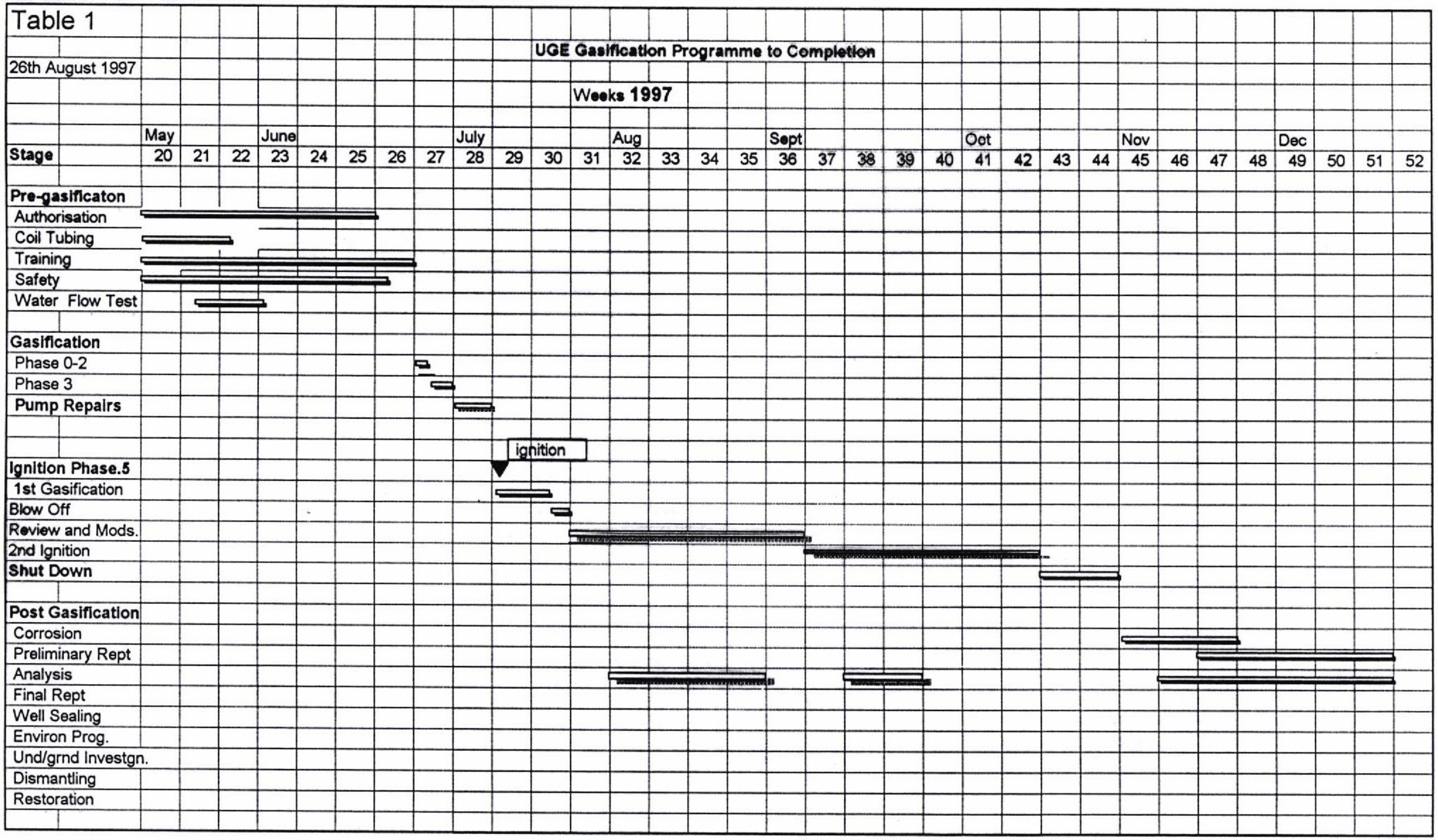

Figure 9. UGE Gasification Programme to Completion

APPENDIX I

PRECISION
TUBE TECHNOLOGY

QC Lab Report

P. O. Box 24746 • Houston, TX • 77229 • (281) 458-2883 • Fax (281) 458-2886

Title **Fatigue Testing ER97-35**

Description 1.750 & 1.880 / 316L Stainless Steel Tubing

Background Information

Part 1: 9 pieces of coiled tubing total

(5) 1.880Ø X 0.102

(4) 1.750Ø X 0.102 (butt welds)

Part 2: Total of 3 samples of welded coiled tubing

(3) 1.750Ø X 0.118 - 0.123

Visual Examination

The as received specimens were carefully examined visually.

Testing Instructions

We received a fax sheet with a list of samples to be tested. First shipment, we received 9 samples. Second shipment we received 3 samples. All butt welded samples were 100% X-rayed in accordance with PTT specifications. We used a 72" radius on the fatigue machine and ran internal pressure at 600 and 3000 psi as requested. All welds were run on the radius. Samples were measured for actual outside diameters before and after testing. The number of cycles was recorded after fracture and the time elapsed was also recorded. Standard test forms were used.(see fatigue testing data sheets)

Summary of Testing

Part 1

We received 9 pieces of coil tubing from Dowell Schlumberger (France), approximately in mid March. We started testing on 3/17/97, and ended on 3/24/97. We followed instructions by Andrew Zheng from Dowell Schlumberger to use a 72" radius with 600 and 3,000 psi internal pressure. Documentation supplied made identification easy. We spent approximately 93 man hours on part 1 of the project. This includes 8 hour's x-ray (actual x-ray, developing, interpretations, and preparing of reports). 32 hours of set up time on fatigue machine (including welding fittings on the end of 1.750Ø tubing to adapt to fixtures for testing), 53 hours running time.

Part 2

Three pieces of coil tubing was received in mid April. Testing started 4/23/97 through 4/24/97. We spent approximately 23 man hours on part 2 of the project. This includes ten hours of set up time on fatigue machine, 13 hours running time.

Total project hours: 116

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Summary of Fatigue Testing
Part 1 (see Chart Below)

Tests No.	Grade	Internal Pressure	Diameter Growth	Fatigue Cycle Failure
1	316L SS	-3000	2.193 / 2.332	145
2	316L SS	3000	2.003 / 2.402	179
3	316L SS	3000	2.215 / 2.316	120
W2	316L SS	600	1.720 / 1.891	1764
W3	316L SS	600	1.748 / 1.795	897
W4	316L SS	600	1.749 / 1.805	1089
W5	316L SS	600	1.754 / 1.767	618
4	316L SS	600	1.928 / 1.958	1761
5	316L SS	3000	2.240 / 2.312	137

Summary of Strip Testing
Part 1

Test No.	Dia.	Gauge	Yield (psi)	Tensile (psi)	Elong.
1	1.880	0.101	46,700	84,300	51
2	1.880	0.102	48,200	84,200	53

Summary of Fatigue Testing
Part 2 (see Chart Below)

Tests No.	Grade	Internal Pressure	Diameter Growth	Fatigue Cycle Failure
1	316L SS	3000	1.906 / 1.969	577
2	316L SS	3000	1.950 / 2.060	666
3	316L SS	3000	1.991 / 2.067	540

Summary of Strip Testing
Part 2

Test No.	Dia.	Gauge	Yield (psi)	Tensile (psi)	Elong.
1	1.75	0.123	42,400	85,800	47
2	1.75	0.115	66,300	90,100	40
3	1.75	0.118	67,000	90,200	40

Submitted April 25, 1997

Nick Morris
Sr. Inspector
Quality Control

(LR97-06)

APPENDIX 2

Sample Analysis of Product Composition

Gas Composition

a)	Main Constituents	CO CO_2 H_2 N_2 NH_3 H_2S CH_4 C_2 H_6 C_3 H_8 C_4 H_{10}
b)	Sulphur Compounds	Carbonate, mercaptanes, CS_2
c)	Hydrocarbons	Alkanes and alkenes to C_6 toluene
d)	Nitrogen	HN_3, HCN

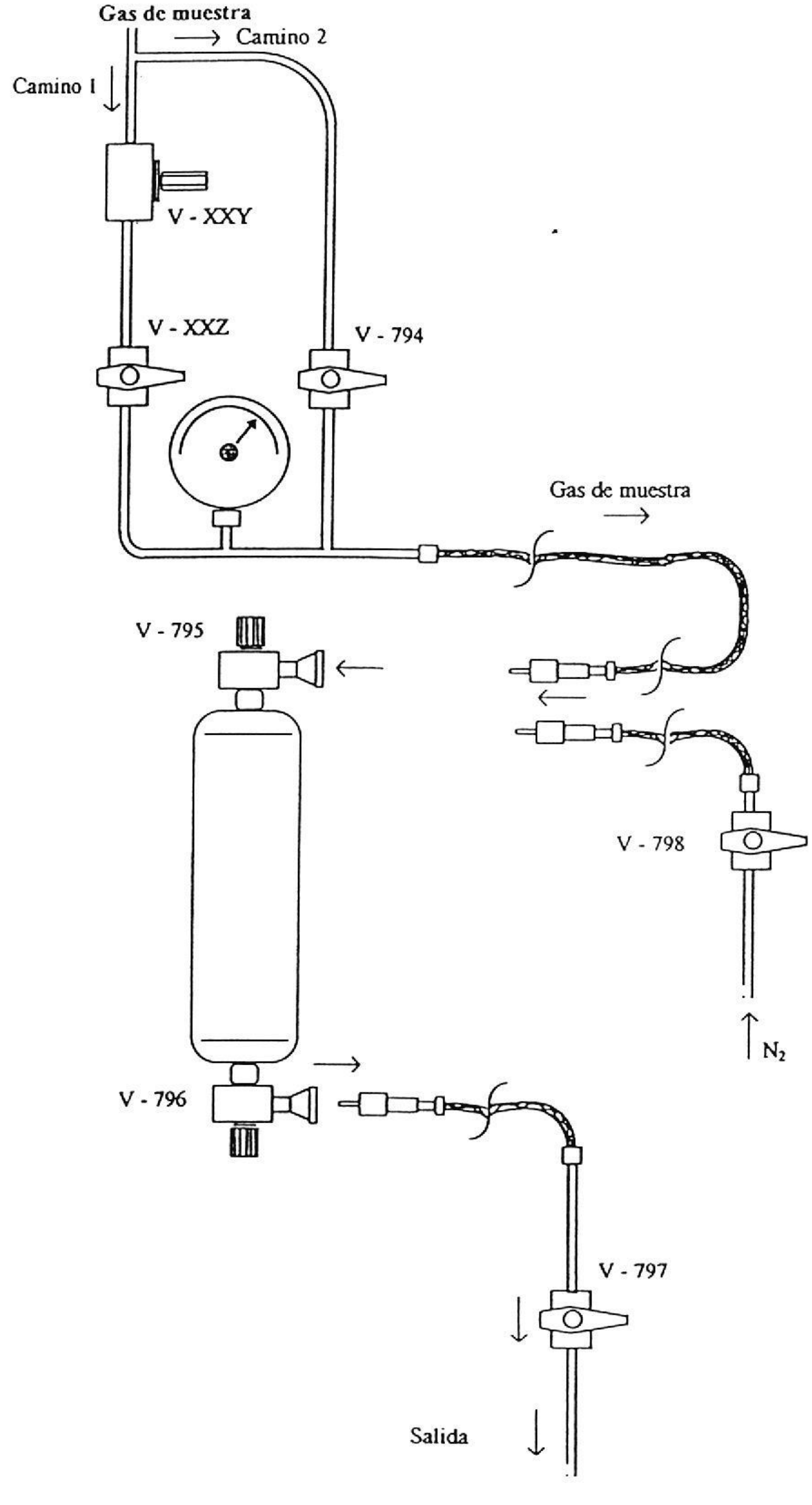
Condensed Liquids & Purge Water

1)	Fractions	condensable organics inorganics	not and fraction fraction
2)	Analysis	inorganics	all tracer metals, amonium SO_4^{++},SO_3^{++}, CL,NO_3 F, CN, $(CN)_3$, ph, conductivity, total carbon, active oxygen, total and suspended solids.
		organics	ketanes, aromatics phenols, piridines and anilines

Solids

All tracer metals
elemental analyses
particle....?

APPENDIX 2



GAS SAMPLING SYSTEM

CONCLUSIONS

UGE staff performed a good and complete analysis of the UCG Process Phases that has been reflected in the Operation Manual Draft.

The main topics discussed during the meeting (which are summarised below), will be taken into account to develop the second version of the Operation Manual.

Apart from suggestions, the topics that are really new (subjects which were not discussed by the UGE staff), and affect what was presented (1st version), are signalled by an asterisk (*):

1.- Phase 1-B: Pressure test.

The pressure target will be 20 bar instead of 30 to avoid damaging the formation.

The solids collected will be checked to confirm if the communication is done through the coal or the sand. **(*)**

2.- Phase 2-B: Water Nitrogen exchange.- Blow Off

The end criteria of the Blow - Off was clarified by Mr. M. Mostade: This phase finishes when the regimen is stable.

If we note water plugs and unstabilities, the way to proceed could be the following:

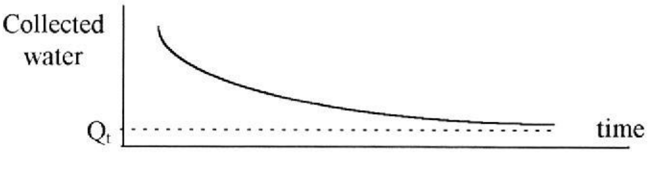
· First, by a remarkable increasing in the water lift conditions.

· Then, by handling manually the Choke valve to avoid water plugs and instabilities.

3.- Phase 2-C: Water Nitrogen exchange.- Nitrogen lift conditions

The influence of the Counter Pressure in the cavity behaviour should be checked.

End Criteria clarification: This phase will finish when the collected water values are stabilised within a range of the final tendency:



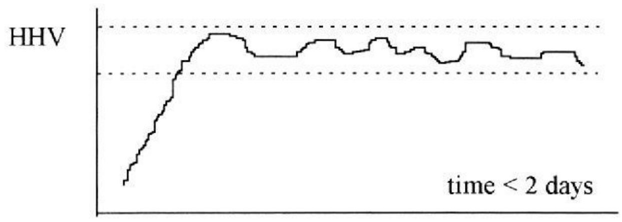
4.- Phase 5-A: Ignition. Test of the final linking under hot conditions

During ignitions (in general), pressure inside the reactor should be increased slightly above the static pressure value to avoid the water influx. **(*)**

5.- Phase 6-A: Stabilisation with air.

Clarification: This phase has two end criteria:

1. Time criteria: 2 days is the maximum available time for this phase.
2. If the final HHV of the product gas does not change notably (within the 20% of the tendency we must pass to the following phase):



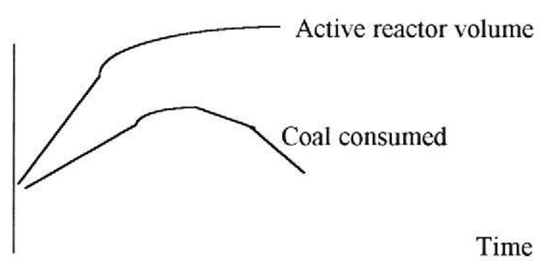
The objective of this phase was clarified by Mr. Mostade: The target is to achieve the gasification with air (not the combustion), but with a limit constraint.

6.- Phase 6-B: Channel Gasification

- The best and easier way to operate is by fixing the ratio $H2O/O2$ and change the O2 flow when necessary.
- Nevertheless, during stable phases the ratio and other parameters like the foam must be checked in order to observe their influence.

7.- Phase 6-C: Channel Gasification.- Helium Tracer Test

- The coal consumed and the active reactor volume could be important parameters to check whether the gasifier is being run out or not:



8.- Phase 6-D: Channel Gasification.- Second CRIP manoeuvre

One Tracer Test should be carried out just before moving to the second CRIP location.

One window will be opened 30 cm below the limestone at 568 m of measure depth, in the IW1. The 2nd CRIP position will be at the RW Casing outlet. **(*)**

What if discussion:

To avoid any problem related to the burner during the ignition procedure, we must retract the Coiled Tubing some centimetres, just before stopping the CH_4 injection **(*)**

Once the ignition at the 1st CRIP location has been performed and the burner is inside the vs22 Liner, the O_2 supply fails. What to do ? These different options will be considered: **(*)**

- Keep the well under pressure if possible and when the retrieve the O_2 again, open a window in the vs22 (is difficult but possible).
- Other alternative could be to restart or revive the last combustion area by injecting a rich O_2 stream, together with a TEB injection (similar to a injection procedure but with some variations).

Suggestion: When there are unstabilities and not clear behaviour of the collected flow, in order to avoid changing from the HFL to the LFL when the product gas decreases, we can inject a Nitrogen stream into the LFL to balance the flow gas decrement.