No 28

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

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TECHNICAL REPORT
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Summary

This report is the tenth technical report of the Underground Coal Gasification project being conducted in North Teruel, Spain, with financial support under the EU's THERMIE energy programme. The report describes progress in both underground and surface construction and commissioning during the period July-December 1996.

The major activities during the period of this report were the final stages of plant construction, plant commissioning, repairs and rectification of deficiencies identified during commissioning, and a first attempt to install the coiled tubing in Injection Well [IW1(ET4)].

Commissioning of plant and equipment began in November 1996, numerous defects and deficiencies being discovered. Commissioning activities will continue in early 1997.

Further analysis of the geology at the site revealed serious concern for the potential success for demonstration of one of the concepts of gasification originally planned to be tested at the El Tremedal site, and resulted in a major change in technical strategy.

1. INTRODUCTION

At end-June 1996, mechanical construction of the surface plant was still incomplete, this situation being due mainly to delay in the supply of replacements for sub-specification valves, expected August 1996.

The main pipework issues outstanding at end-June 1996 were resolved; these being replacements for sub-specification gate valves in product gas lines, and a solution to achieve pressure-tight connections of small valves in wellhead/manifold lines.

The construction supervision contractor (SERELAND) failed to provide services from Mid-August 1996, extortionate additional payments and contract renegotiation being demanded as conditions for continuation of contract services. Construction and commissioning work took place from this date to the end of the period of the report without supervision services from SERELAND.

An omission in surface engineering design was discovered; the stresses on surface pipework due to product well expansion had not been taken into account, and analyses of these stresses and the means to accommodate them were investigated. A solution involving piping support modifications will be implemented early 1997.

Manufacture of special components for the coiled tubing unit were under construction, and completion of the unit was expected July 1996. Preparations for commissioning were in progress, in order that this phase be initiated immediately on completion of plant construction.

2. SURFACE PLANT

2.1 MECHANICAL CONSTRUCTION

Product gas lines valves

Delivery of the replacement gate valves for the product gas lines by Malbranque, expected end-July, was delayed, the valves being delivered to site and installed during October 1996.

Oxygen lines valves

Pressure tight connections had been a problem in 1/2" & 1" valves in manifold/wellhead lines, a large number of valve connections having failed hydraulic test. Although sub-standard NPT threads were suspected, the manufacturer, Redfluid, inspected the valves on site and confirmed that manufacturing tolerances were within specification. Incompatibility of the tolerances of different valve and connector manufacturers was proposed as the most likely cause of failure; all the valves were returned to the manufacturer for remachining, as a result of which the leakage problem was resolved.

Other valves

Additional defects/deficiencies were revealed in valve installations. The packing in some oxygen line valves were found to be of graphite, unsuitable for oxygen service, and were replaced by Teflon special packing.

"O" ring seals installed in some valve flange connections in oxygen lines were found to be of mild steel, again unsuitable for oxygen service, and were replaced by stainless "O" rings.

These supply/installation defects demonstrated the lack of attention of the contractors to the special requirements for oxygen lines.

Product well expansion

An omission in surface plant design was identified: the need to accommodate, into the design of surface pipework of the recovery lines, for stresses resulting from potential production well expansion, due to high bottom hole temperature and product gas temperature. The concern regarding well expansion arises from the poor cementing near surface of the 9.5/8" casing of the product well, indicated by the results of a CBL (Cement Bond Log) survey. From this log it appears that the cement integrity of the upper 60 metres of cement cannot be relied upon, and that this section of casing could expand above ground level as a result of heat transfer from the product gas tubing.

Mid-96, on the basis of the maximum recovery wellhead expansion estimation, the engineering contractor SERELAND was requested to conduct an analysis of the resultant stresses in surface pipework, and their possible means of accommodation via the installation of appropriate supports. The solution and dimensioning proposed was considered to be less than satisfactory, and another engineering company (PIHASA) was requested, in September 96 to conduct analysis of an improved support layout.

A temperature well simulation model of I.D.G.S. was also run to obtain an estimate of the maximum expected casing temperature over the duration of the gasification phases of the project. A simple calculation of the potential expansion was estimated from this temperature assessment. As a safety factor, the assumption of no restriction to expansion was taken.

When PIHASA stress analysis and suspension support proposal was received, a complete review of the dimensioning was done with TRACTEBEL, in Belgium, for confirmation. This was done in order to avoid major failure in the production lines during gasification phases.

The solution involving new piping supports and line reinforcements will be implemented early 1997.

2.2 COMBUSTOR CONVERSION

Initial modelling of product gas composition suggested that the expected minimum calorific value of gas required to be burnt would be in the range 500-700 kcal/kg. The initial design and construction of the combustor provided for a stable combustion flame for this minimum calorific value.

Further modelling and assessment suggested that gas of very low quality would be produced during shut-down phases of the gasifier, and the possibility of low quality gas cannot be ruled out as a result of unexpected underground events. Because neither combustor nor flare could be guaranteed to burn low quality gas, it was considered prudent to convert the combustor to provide the ability to burn gas of any quality (operation as an incinerator).

The conversion to be effected will involve the mixing of fuel gas with product gas to achieve a mixture of minimum calorific value of 700 kcal/kg for combustion in the existing burner. The following additional components were ordered, and will be installed in February 1997:

- Equipment (valves, filters etc.) to inject propane into the base of the flame (mixing with product gas)

- Second photocell sensor, for additional safety in detection of the main flame

The control system of the incinerator will be reprogrammed to control the unit in the new configuration.

2.3 ELECTRICAL / INSTRUMENTATION

Completion of the Electrical (EDASA) and Instrumentation (DUMEZ COPISA) contracts continue to await the small number of outstanding items required for completion of the mechanical construction.

A new sensor was selected to be installed on the recovery well to monitor its potential expansion during gasification phases.

2.4 PRODUCT GAS ANALYSIS UNIT

The Site Acceptance Testing (SAT) and pre-commissioning of the unit were performed.

Operational problems were experienced with some minor elements of the unit during the test programme, and will necessitate replacement of damaged components. Completion of pre-commissioning activities are scheduled for early 1997, including a modification to enable glass cylinders to be used for take-off samples for laboratory testing.

Final commissioning of the complete gas analysis unit and testing of the mass spectrometer will be performed after process phase start-up, because operation of the unit requires the condition of reactor gas flow and the control of process parameters in the product gas line.

2.5 HAZOP STUDY AND OTHER OPERATIONAL ANALYSES

The final report on the HAZOP (Hazard and Operability) study was received from TECSA in July 1996. The study is a comprehensive analysis of the deviations (especially of pressure, temperature and flow) which could occur in flow lines of the surface plant, together with their causes and consequences. Recommendations of the report included the following proposals:

- Installation of automatic shut-off of oxygen control valve
- Installation of additional alarms
- Connection of certain control valves to emergency power supply
- Verification of relief and control pressures
- Confirmation of check valve reliability/procedures

The conclusions and recommendations of the HAZOP analysis were evaluated by UGE to determine which of the proposed modifications to equipment and control strategies should be incorporated into the plant, and which were unnecessary. The following considerations were taken into account:

- probability of a deviation to occur and the possibility of detection
- the extent to which the deviation identifies the supposed cause and consequence
- the presence of elements already existing to avoid the consequence
- importance/nature of the consequence
- viability of incorporation and efficacy of the recommendation

The results of the UGE appraisal can be summarised as follows:

- Acceptance of all recommendations for alarm generation in the Control System to inform the plant operator of the situation
- Several situations identified are already covered by adequate safety elements installed in the plant: check valves, relief valves etc.

The following changes to equipment and control strategies were accepted and implemented:

1. Automatic shut-off of oxygen supply in the event of high oxygen line pressure.

2. Automatic shut-down of Process Water Pumps in the event of high process water line pressure.

3. Automatic shut-down of Quench Water Pumps in the event of high quench water line pressure.

4. Automatic shut-down of Foam Pumps in the event of high foam line pressure.

5. Removal of connection between N2 lines and He tracer vessels (connected to O2 lines) to eliminate the possibility of O2 flow to N2 lines was still be assessed.

6. Connection of Recovery Well electrical choke valves to the emergency power supply, to guard against loss of control on reactor pressure.

7. Development of a detailed Procedure Manual covering all operations requiring compliance with procedures, (ignition, tracer tests etc.).

In addition to the HAZOP study, TECSA were requested to produce a Laboral Risk Analysis and an Internal Emergency Plan, and these were received in August 1996.

2.6 COMMISSIONING

Although pre-commissioning of some package units in advance of piping completion was possible to minimise delays via the early identification and repair of faults, safety concerns such as the presence of propane in lines adjacent to welding operations were paramount, and the pre-commissioning of all units prior to piping completion was not allowed.

Commissioning of several package units began in November 1996 although mechanical construction and final electrical and instrumentation connections were still not complete at that date. The decision to conduct partial commissioning in parallel with final construction was taken in order to identify any problems concerning package units at the earliest opportunity. Commissioning was scheduled to cover a duration of six weeks, the estimated completion of these activities being December 1996, assuming no major problems or delays.

The commissioning operations and supervision was done by UGE personnel, due to the supervision contractor (SERELAND) refusing to provide further services.

2.7 COILED TUBING

At end-June 1996 engineering and construction of the coiled tubing were completed by DOWELL-SCLUMBERGER (DS), special components were under manufacture in Norway, while other parts had to come from Italy and UK. All the components of the unit were sent to DS-PAU, for final assembly and pressure test certification, prior to installation on site in November.

Serious problems were encountered on installation of the coiled tubing in injection well[IW1(ET4)]:

a- tube welding was found to be defective, which caused serious questions about safety handling in presence of pure oxygen,

b- the injection assembly (Coiled tubing 1.66" tubing) was unable to be inserted to total depth, which did not allow to perform the projected CRIP injection programme.

In order to address these two unrelated problems, a four steps plan was initiated :

1. remove the whole injection assembly (Coiled tubing and lower 1.66" tubing)
2. assess the blockage
3. investigate cause of welding failure and decide on the new assembly design
4. re-run the new assembly

The first step was performed in December, the whole coiled tubing unit being dismantled, the lower tubing 1.66" cut in 20 meters sections, and all control lines (2 macaronis, 1 thermocouple) coiled back on separate drums.

The second step was performed through a close observation of any damages to the centralizers and 1.66" tubing, and by running a calliper log. The calliper confirmed the absence of any obstruction, ovalisation or deformation of the 6 5/8" liner. All centralizers were within tolerance and were not presenting any abnormal wear.

Steps 3 and 4 will be performed in early 97, after serious discussions with the service company (DS) and other coiled tubing manufacturer.

Although the cause of the inability to insert the tubing had not yet been determined at the end of the period of this report, it was clear that a major revision to the design/construction concept of the system was necessary. Preliminary contacts with coiled tubing manufacturers were taken to assess delivery time and cost.

3. ENVIRONMENTAL MONITORING PROGRAMME

The environmental monitoring programme was described in the previous technical report. The objective of the programme is to detect any possible interactions between the El Tremedal trial and the groundwater hydrology in the area.

Water levels were monitored in four wells continued, and are revealing normal level variations as a base line for future reference.

4. PROCESS ANALYSIS AND MODELLING

The tracer programmes (Helium and D2O) were reviewed for optimisation during the various phases of the trial, and further modelling.

New thermal simulations were run for the production well to confirm wellhead expansion prediction.

A first analysis protocol of the water and gas samples was drafted for laboratory selection, and complete review of the quantities to be sampled, stored and analysed.

5. SUPPORTING PROGRAMME

A meeting of the UGE Scientific and Technical Advisory Group was held at IDGS offices in Liège on 22 November 1996. The agenda items were:

- Reverse Combustion/Pyrolysis and Filtration Gasification Phases
- Foam Viability and Use
- Post-burn Drilling Proposal

Presentations on each of the above were followed by discussion, the main conclusions being as follows:

Reverse Combustion/Pyrolysis and Filtration Gasification Phases

Madam A. Coëme, IDGS, presented the results of a 2-D model simulating flow distribution in the coal seam and its immediate clayey sand roof between injection well IW2(ET6) and the channel created during the CRIP/channel gasification. Model results indicate the risk of an important by-pass of flow through the coal seam roof (Clayey sand roof), and thus in El Tremedal conditions, a large proportion of the injected air would pass quickly into the coal roof, by-passing the coal.

Presentation also focused on the beneficial aspect of permeability anisotropy observed in coal. The permeabilities of the coal and roof strata being those measured previously and other hydrological tests on site, the model concluded to a very low transmission through the coal to achieve effective gasification of the coal by filtration. If permeabilities in cleat directions parallel to the bedding plane are significantly higher than the permeability perpendicular to the bedding plane, flows maintained inside the coal seam could be sensibly increased.

The possible presence of a geological accident (fault provoking a coal bed displacement of approx. 3.9 m - coal seam block at ET6 situated above) between the in-seam interval of deviated injection well IW1(ET4) and injection well IW2(ET6) was also recalled and commented. Depending on fault location, beneficial or reverse effects can be forecasted for reverse combustion/pyrolysis phase success.

If the fault is situated in the vicinity of injection well ET6, flows injected in coal seam will be broken and will follow the clayey sand roof after fault occurrence. If the fault is situated in the channel gasification zone, converging flows will occur through coal seam on top of channel gasification zone.

Discussion was then conducted to determine one of the three possible options for the process operation programme:

- Cancellation of reverse combustion/pyrolysis and filtration gasification phases.
- Maintain reverse combustion/pyrolysis phase and analyse their results, cancel filtration gasification phase.
- Maintain the initial programme of operations including reverse combustion/pyrolysis and filtration gasification phases. The programme of operations foresees a decision point at the end of reverse combustion/pyrolysis phase.

The overall opinion of the UGE Scientific and Technical Advisory Group was that the chance of success of reverse combustion/pyrolysis phase was low, and that serious consideration should be given to the cancellation of reverse combustion/pyrolysis and/or filtration gasification phases as they were foreseen in the initial process phase programme. Nevertheless, it was mentioned that possibility to compare two gasification scenarii could be particularly important for the future of UCG in Europe (thin coal seam at great depth). Width and sweep efficiency of channel gasification in thin coal seam could be limited and this could lead to a non-economical process. In this case, reverse combustion/pyrolysis process followed by filtration gasification could be the only possible economical solution for thin and deep European coal seams.

Taking into account that transverse injection well ET6 is drilled and equipped, surface plant being connected to well ET6, chance of success is not nil and reverse combustion/pyrolysis results could be beneficial for future development of UCG in Europe, UGE Scientific and Technical Advisory Group advices in favour of the second option: maintaining reverse combustion/pyrolysis phase and its result analysis, cancelling filtration gasification phase.

The three possible options for the process operation programme were relayed to the UGE Council in November. As a result it was decided to suspend further preparations for filtration gasification pending notification to CEC of the intention to cancel the filtration phase.

Foam Viability/Use

Mr. M Mostade, I.D.G.S., covered the objectives of the use of foam, its expected behaviour in transport down an injection well, and flow conditions necessary to achieve the expected benefits.

The following risk assessment factors were proposed:

With foam:	More important pressure drop should be expected Flow regime of diphasic liquid not well known Stability of foam inside reactor unknown
Without foam:	Liquid water accumulation inside reactor High Temperature at combustion/injection point

The overall assessment of the Advisory Group was that foam was attractive for solving some of the potential difficulties of operation, but that its use was accompanied by uncertainties. The Group felt that it could be a valuable addition to stable operation, and that its overall benefits were likely to be greater than any problems accompanying its use.

Post burn Drilling Proposal

Pr. J. PATIGNY, I.D.G.S., presented a post-burn drilling programme, including coring, geotechnical surveying and analysis. The presentation covered the objectives of the programme, the methods to obtain information and data on the effects of gasification and the condition of the strata after completion of gasification phases.

Discussion followed on the value of the programme for the planning of future trials and the development of UCG technology. Members of the Group were asked to record their comment on the proposal and to forward these to the Chairman of the Group (Mr. M. MOSTADE) for collation and subsequent transmission to the UGE Council.

6. PROJECT DIRECTION

6.1 AUTHORISATIONS/LEGALISATIONS

Legal authorisation was received for the propane (LPG) storage system and the propane gas line. For the boiler, electrical installation, cryogenic plant, combustor and flare, the legalisation were in progress.

Approval was received from DGA for the production, storage and disposal of foul water during let-down and shut-down operations of the gasifier, subject to proof of:

a- insurance to cover civil responsibility and decontamination costs.
b- a toxic residuous registration book
c- a confirmation from a registered company accepting the treatment and disposal of the waste.

Intensive negotiations were conducted with a pool of insurance to cover major underground damages (water contamination,...), in order to comply with DGA recommendations. It is hoped that by early 97 a suitable proposal will be found.

6.2 PERSONNEL

In replacement of Mr. M. MOSTADE from 1 September 1996, Mr. Ph. FIEVEZ was nominated as Deputy Director - Technical. He is a mining Engineer, with 10 years experience in an oil / gas service company (drilling, coring, ...), and was previously the former site supervisor of the IDGS (Thulin) gasification trial.

The services of one engineer and four technicians were contracted, for the commissioning period, to the engineering service company SIEMSA, providing experienced personnel at lower cost than via direct employment. Four more technician will be called for the start-up of the trial operations in 97, in order to cover all the necessary manpower for 24hr / day.

6.3 TRAINING

Training about the plant installation for UGE engineers and contracted technicians is being effected by providing complete technical presentation of each package unit / equipment built on the site. Familiarity was gained with the operation of plant and equipment on site during commissioning. Safety training have been organised by specialised company.

Additional training for UGE engineers is being provided during the presentation and in depth explanation of the Process Phases Operations Manual, to cover step by step the sequences of plant operations to achieve and transition between process phases.

6.4 CHANGES IN TECHNICAL STRATEGY

Further analysis of the site geology and the expected flows in coal and roof strata (see pt5) revealed serious concern for the potential success for demonstration of one of the concepts of gasification at the El Tremedal site, and resulted in changing the technical strategy. UGE council took the decision to suspend preparations for filtration gasification pending notification to CEC of the intention to cancel the filtration phase.

6.5 EUROPEAN WORKING GROUP

The proposal "Underground Coal Gasification - Dissemination of Results of Existing Project and Formulation of Future Programme" was favourably evaluated by the European Commission. An offer of financial contribution of up to 80,000 ECU to a total project cost of 130,000 ECU was received, this total cost being 60% lower than that proposed to CEC.

Views of UGE Members and NOVEM, initiators of the proposal, in response to the offer and reduced budget were requested, in the knowledge that the extent of work would need to be severely reduced to keep within the revised budget proposed by CEC. It was agreed to accept the offer of financial aid and a contract with CEC was signed in December 1996.

6.6 CONFERENCES, PUBLICATIONS AND REPORTS

Hazard and Operability Analysis (HAZOP) of the Plant, TECSA IBERICA s.a., Contractors Report Nº 77, June 1996.

Plan de Emergencia Interior, TECSA IBERICA s.a., Contractors Report Nº 80, August 1996.

Evaluacion de Riesgos Laborales en la Empresa Underground Gasification Europea A.E.I.E. de Alcorisa, (Teruel), TECSA IBERICA s.a., Contractors Report Nº 81, August 1996.

Informe Sobre la Situación Actual de las Obras, INGENIERÍA, ESTUDIOS Y CONSULTORÍA, s.c., Contractors Report Nº 84, November 1996.

Informe Sobre la Documentación de las Obras, INGENIERÍA, ESTUDIOS Y CONSULTORÍA, s.c., Contractors Report Nº 85, November 1996

Layout and Description of the Wells, UGE Internal Report 137/IN/96/E, M. Mostade, July 1996.

HAZOPS Analysis, Underground Coal Gasification Plant, UGE Internal Report 139/IN/96/E, F.Adrián, August 1996.

Equipment and Software General Description (DACS), UGE Internal Report 142/IN/96/E, F. Adrian, October 1996.

Manual Unidades Paquete, UGE Internal Report 148/IN/96/S, A. Hidalgo, November 1996.

COMMISSIONING STATUS

DATE: 31/12/96

COMPANY	UNIT	
Carburos Metálicos	N_2 Low Pressure	Commissioning performed.
Carburos Metálicos	Nitrogen High Pressure	Working provisionally pending of pump-heads repair.
Carburos Metálicos	Oxygen High Pressure	Commissioning not started.
Cepsa	Propane	Important problems found. Gas phase: in working order. Liquid phase: vaporizator and hot water boiler must be changed.
Sogecal	Steam Boiler	Commissioning performed. To improve its performance a venting valve will be installed.
Proyce	Combustor, Flare	Pre-commissioning not started. Conversion of combustor into incinerator in progress.
Bran Luebbe	Water Pumps	Commissioning performed.
Dowell Schlumberger	Coiled Tubing	Importante problems: Unability to get the assembly to the target point and weld leak. Search of alternative solutions in progress.
Solarca	Lines Cleaning	Performed.
Solarca	Wells Cleaning	Waiting for coiled tubing solution.
Denion Control	Gas Analysis Unit	Pre-commissioning not finished. A few improvements to perform and staff training to be completed.

Remark: As product gases are required, Combustor, Flare and Analysis Unit will be commissioned at the beginning of gasification.

TESTS

COMPANY	UNIT	
Edasa	Emergency Generator Grounds, Electrical Consumption	Tested. In good working order. Not performed.
UGE	Cocooning	Yes. Lines under 3 bar pressure for winter period protection.
UGE	N_2, O_2 Distribution, Pressure Test	Not performed.
UGE	Heat Exchangers in Production Line	Not performed.
UGE / Denion	Gas Analysis Unit	Not performed.

COMMISSIONING PLANNING

DAY NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
DATE NOVEMBER/DECEMBER	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22	25	26	27	28	29	2	3	4	5	9	10	11	12

COMPANY	UNIT	IN CHARGE
CARBUROS METÁLICOS	N2 LOW PRESSURE	AHB, JLC
CARBUROS METÁLICOS	N2 HIGH PRESSURE	AHB, JLC
CARBUROS METÁLICOS	02 HIGH PRESSURE	AHB, JLC
CEPSA	PROPANE	AHB, JLC
SOGECAL	STEAM BOILER	AHB, JLC
PROYCE	COMBUSTOR, FLARE	AHB, JLC
BRAN LUEBBE	WATER PUMPS	AHB, JLC
DOWELL SCHLUM BERGER	COILED TUBING	AH,HH
SOLARCA	LINES CLEANING	JC
SOLARCA	WELLS CLEANING	CB
DENION CONTROL	GAS ANALYSIS UNIT	JC, FA
DENION CONTROL	INSTRUMENTATION	JC

TESTS

COMPANY	TEST	IN CHARGE
EDASA	GROUNDS, ELECTRICAL CONSUMPTION, ELECTROGEN GROUP	AHB, JLC
UGE	COCOONING	AHB, JLC
UGE	N2, O2 DISTRIBUTION, PRESSURE TEST	JLC
UGE	OPERATIONAL TEST (HEAT EXCHANGER, PRODUCTION LINE...)	HH
UGE / DENION	GAS ANALYSIS UNIT	JC, FA
DENION CONTROL	INSTRUMENTATION FINAL TEST	JC, FA

PERFORMED
IN PROGRESS
IMPORTANT PROBLEMS
NOT STARTED