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MEETING
PAPER



TERSANNE AND ETREZ UNDERGROUND STORAGES

Leaching forecast and simulation
of cavities in salt layers with insolubles

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ABSTRACT

Since 1968, GAZ DE FRANCE and its subsidiary SOFREGAZ have mastered the technique and acquired experience in solution mining of salt cavities for underground storage. The two main projects of natural gas storage at Tersanne and Etrez will respectively include fourteen cavities by 1985 and twenty-eight cavities by 1998, 200,000 cubic meters each.

Computer and control means have been set up to ensure large scale industrial realizations in optimum conditions of automatization and safety.

RESUME

Depuis 1968, le GAZ DE FRANCE et sa filiale SOFREGAZ ont acquis la maîtrise et développé leur expérience en matière de creusement par dissolution des cavités salines destinées au stockage souterrain. Les projets de stockage de gaz naturel de TERSANNE et d'ETREZ comprendront respectivement quatorze cavités en 1985 et 28 cavités en 1998 d'un volume de 200 000 m³ chacune.

Des moyens de calcul et de contrôle ont été mis au point en vue de réalisations industrielles à grande échelle dans des conditions d'automatisation et de sécurité optimales.

1 - INTRODUCTION

Since 1968, GAZ DE FRANCE and its subsidiary SOFREGAZ have mastered the technique of and acquired experience in solution mining of salt cavities intended for underground storage.

The purpose of this paper is to present the major results of this experience.

The plan of this expose will be as follows :

- presentation of industrial installations carried out by GAZ DE FRANCE and SOFREGAZ in terms of underground storage in salt cavities,
- presentation of computer means implemented to carry out and control these industrial installations,
- organization of the carrying out and control of salt cavities leaching,
- finally, a special chapter is dealing with the means implemented to ensure the safety of storages in salt cavities.

2 - INDUSTRIAL INSTALLATIONS

2.1 - TERSANNE AND ETREZ UNDERGROUND STORAGES

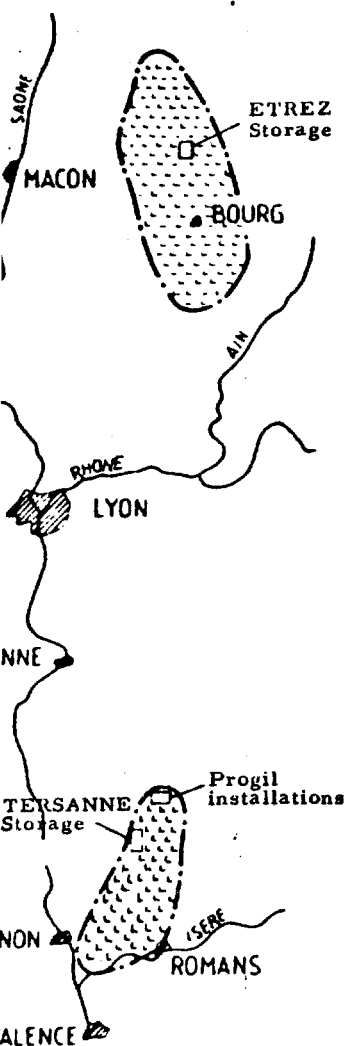
The experience acquired by GAZ DE FRANCE and SOFREGAZ is first of all based on two projects being carried out at present by GAZ DE FRANCE in South East France (Figure 1).

The first of these projects is now coming to an end. It is that of Tersanne, located 90 km South of Lyon.

The second project concerns the site of Etrez located 85 km North of Lyon.

In both cases, the cavities are leached out of salt layers belonging to tertiary evaporitic deposits (Oligocene) and being part of a succession of salt basins stretching from Alsace to the Camargues.

The leaching technique used is that of direct fluid circulation : the leaching fluid, fresh water in Tersanne and Etrez (sea water can be used just as well in the case of sites located by the sea side) is injected through the bottom of the cavity and the brine produced is withdrawn at the top.



TERSANNE

Depths Ground	Section	Stage	Lithology	Cavity Locations
240 - 350		SUP. HELVETIAN	Medium grained sand and locally clayey sandstone	
		INF.	Streaks of grey clay Medium to coarse sand	
		CHATTIAN	Alternance of - grey and coloured clay - medium grained sand	
790 - 930		AQUITANIAN	Calcareous clay Glauconitic clay Gypsum clay	
			Medium to coarse grained sand with bands of clay	
		ANHYDRITE CHATTIAN	Dolomitic limestone Fibrous anhydrite - Gypsum Dolomitic clay	
900 - 1050		STAMPIAN	Grey clay	
1360 - 1510			Grey calcareous clay	
			Streaks of anhydrite Massive salt and rognon-shaped anhydrite	
1510 - 1700		SANNOISIAN	Alternance of - salt and anhydrite - clay Streaks of dolomitic limestone Salt with bands of clay	

ETREZ

Depths Ground	Section	Stage	Lithology	Cavity Locations
125 - 130		PLIOCENE	Alternance of clays, sands and marls - Presence of lignite layers	
		PONTIAN	Marls	
325 - 350		TORTONIAN	Sands	
410 - 445		AQUITANIAN	Marls Limestones	
460 - 520			Clayey limestones Anhydrite	
			Anhydrite marls	
			Macrocrystalline salt abounding in inclusions and beds of clay	
650 - 700				
800 - 850		STAMPIAN	More pure macrocrystalline salt	
950 - 1000			Macrocrystalline salt Numerous inclusions of marls and clayey limestones	
1095 - 1140			Anhydrite marls and salt in alternance	
1300 - 1350				
1900 - 2000		SANNOISIAN	Macrocrystalline salt Inclusions of marls or clays closed in upon lenses of anhydrite	
			Anhydrite Marls	

Limit of saliferous basin

The main characteristics of these two projects of natural gas storage are as follows :

	Tersanne	Etrez
Beginning of leaching operation	1968	1977
Expected final date	1985	1998
Final installation :		
- number of cavities	14	28
- maximum storage capacity (10^6 Nm ³)	475	1 000
Present installation :		
- number of cavities being leached	4	5
- number of cavities being operated	10	5
Standard volume of cavities (m ³)	200 000	200 000
Depth of cavity roof subground (m)	≈ 1 400	≈ 1 300
Leached height of salt (m)	140 to 180	140 to 180
Height of standard cavity (m)	80 to 120	80 to 120
Maximum diameter of standard cavity (m)	≈ 80	≈ 80
Average percentage of insolubles in the salt layer	8 %*	14 %**
Variation intervals of operating pressure for gas storage (bar)	80 to 220-240	80 to 210-230

* as compact layers

** dispersed

The main leaching equipment implemented on each site,
at Tersanne and Etrez, is as follows : *

Sites		Tersanne	Etrez
Fresh water supply	Coming from	Miocene sands - 150 m/ground level	Tortonian sands - 350 m/ground level
	Immersed pumps	5 Unit flow rate : 100 m ³ /h	5 100 m ³ /h at 10 bar
	Storage	1 x 800 m ³ open air basin	10 x 100 m ³ tanks under nitrogen top accumulation
Leaching pumps (centrifugal type)	Medium pressure header	4 x 70 m ³ /h pumps at 55 bar	4 x 70 m ³ /h pumps at 55 bar
	High pressure header	2 x 100 m ³ /h pumps at 80 bar	3 x 130 m ³ /h pumps at 120 bar
Completion of well for leaching		7" - 4"	7 5/8" - 5"
Brine evacuation	Storage	1 x 2,000 m ³ open air	10 x 100 m ³ tanks under nitrogen top accumulation
	Pumps (centrifugal type)	4 x 80 m ³ /h pumps at 15 bar	3 x 250 m ³ /h pumps at 50 bar
	Average sending flow rate	200 m ³ /h	300 m ³ /h
	Destination**	Compagnie Industrielle & Minière at Hauterives	Société Solvay at Poligny
	Brine pipe	cast iron Ø 250 mm - L = 7 km	steel Ø 400 mm - L = 75 km automatic system for oxygen reduction

* The surface equipment relating to natural gas storage operating is not expounded in this paper.

** For saturation, then sending to a chemical plant for chlorine and soda extraction.

Each site has a central control room provided with a mimic panel.

At Tersanne, the flow, pressure and temperature measurements carried out on water injected and brines produced are sent to the control room.

At Etrez, the leaching installation, being more recent and therefore more modern, enables the additional sending to the control room of the sodium chloride concentrations of the brines produced as well as the direct acquisition of all these measurements on a mini computer. In addition, the control valves regulating the various injection flows on the wells being leached simultaneously are remote controlled from the central control room.

On each site, at Tersanne and Etrez, each platform of a well being leached is provided with skid-mounted equipment (valves, pumps, meters) intended for the fuel injection and withdrawal operations required by the leaching control at the cavity roof (cf. paragraphs 3.2.5 and 4.1.1). This equipment called "fuel skids" is operated in automatic sequences and remote controlled from the central control room.

In addition to these "fuel skids", the following equipment is found on each platform of wells being leached :

- four fuel storage tanks (of 30 m³ tanks and one tank for decantation),
- one separator used for separating fuel from the brine produced by leaching in case of overflow and equipped with a fuel detector (cf. para. 3.2.5 and 4.1.1).

All this equipment installed on each platform of a well being leached is represented on Figure 2.

* Fuel is used both at Tersanne and Etrez as inert fluid for leaching control at cavity roofs.

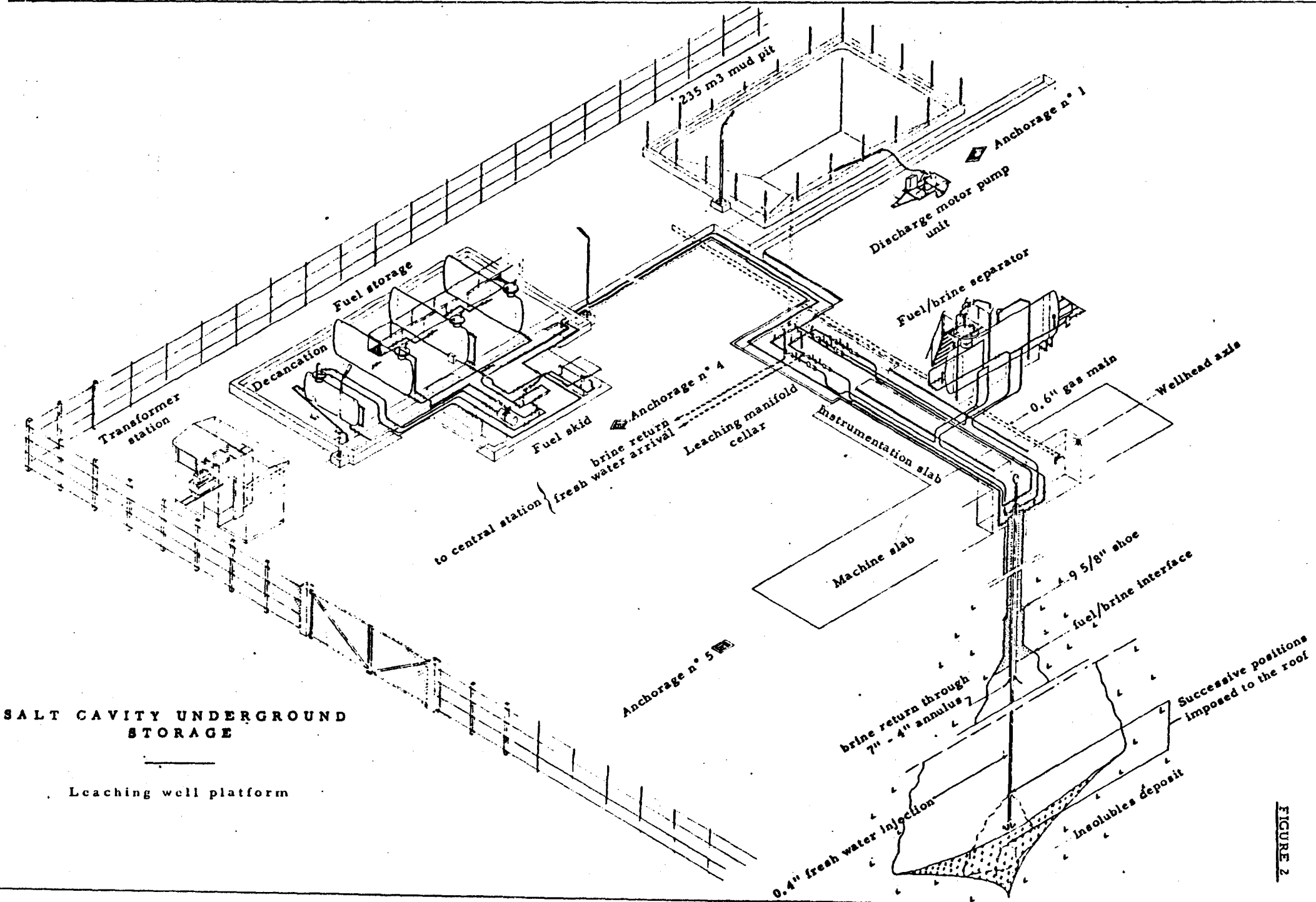


FIGURE 2

2.2 - THE OTHER PROJECTS OF GAZ DE FRANCE AND SOFREGAZ

In addition to these two projects being carried out at present by GAZ DE FRANCE, the following projects must be mentioned :

- in the 1970's, construction of a propylene storage cavity of 60,000 m³ at Grand-Serre, near Tersanne, lead by GAZ DE FRANCE on behalf of RHONE-POULENC,
- planning and early engineering of the project of natural gas storage cavities at Hornsea, Great-Britain, with the assistance of SOFREGAZ on behalf of British Gas Corporation,
- a construction project of five salt cavities for the storage of LPG at Kirkuk, Iraq, lead by SOFREGAZ on behalf of Northern Petroleum Organization is in progress.

3 - COMPUTER MEANS IMPLEMENTED

3.1 - SETTING-UP OF THE LOGSEL

In order to carry out and control the solution mining of salt cavities, a knowledge as precise as possible of the materials forming the salt massif to be leached and of their distribution within the massif is required.

At GAZ DE FRANCE and SOFREGAZ, such knowledge is synthesized in the LOGSEL which gives the clay and anhydrite contents in relation to the depth along the vertical of the well to be leached (Figure 3).

These contents are automatically determined by a computer programme combining two by two the results of the following well loggings : gamma-gamma (formation density), neutron and sonic, after calibration of these well loggings based upon the analyses carried out on samples taken in-situ.

FIGURE 3

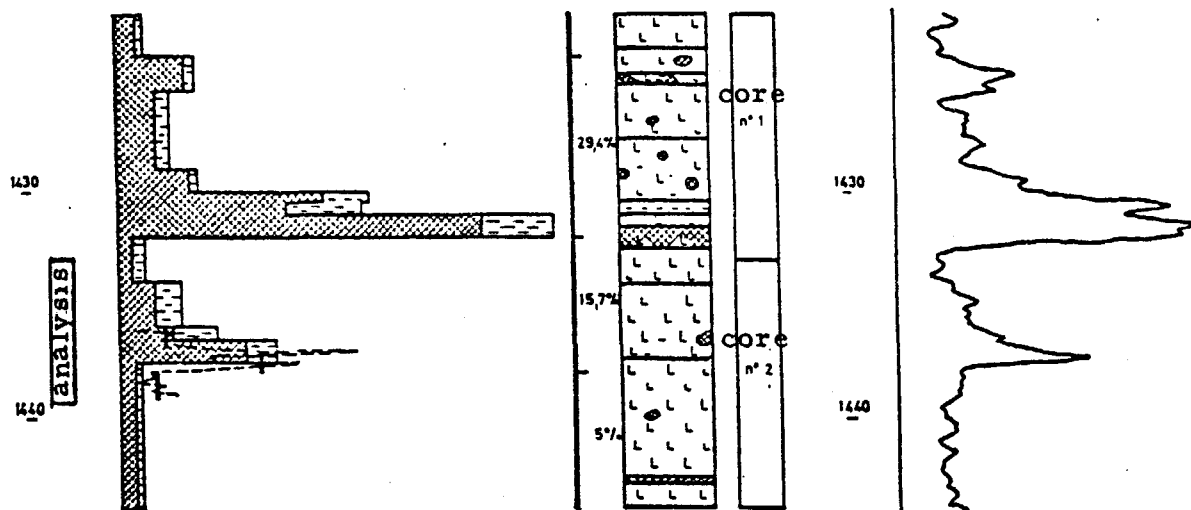
Scale
of depths : 1/300

LOGSEL : insolubles content

Lithology

Formation density

well logging result. { % clay
% ANHYDRITE } analysis result
% sample
% average



3.2 - COMPUTER PROGRAMMES RELATING TO LEACHING

3.2.1 - Theoretical bases

The theoretical bases of the computer programmes used by GAZ DE FRANCE and SOFREGAZ were taken from the work of Durie and Jessen (1964) on the dissolution of salt by natural convection at laminar flow. Results were transposed to the case of turbulent flow with sub-laminar boundary layer which corresponds to the conditions found in a cavity leached directly. It is important to note the homogeneity of brine along the walls of a cavity directly leached.

3.2.2 - Cavity geometrical development simulation computer programme

The original characteristics of the techniques developed by GAZ DE FRANCE is that they enable making ogival-shaped cavities, a shape which in terms of mechanics is considered as the most stable.

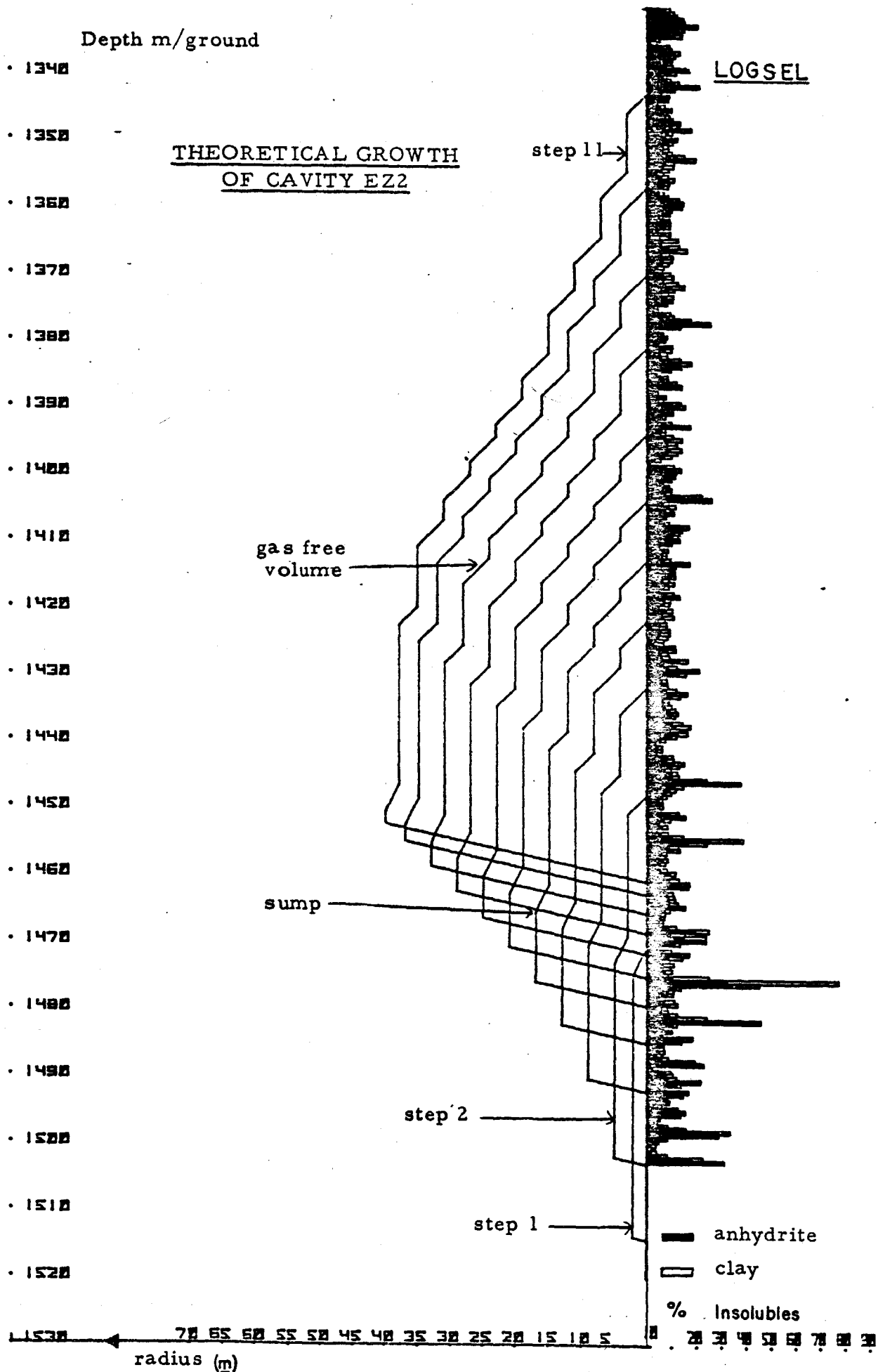
In order to obtain such a shape, cavities are mined out in successive steps (Figure 4). At each step, a truncated cylinder and a truncated cone are added to the previous shape. From one leaching step to another, the fresh water injection and brine evacuation tubing string shoes are raised by a certain height, the distance between both shoes increasing as the cavity develops. The number of steps and the positioning of the tubing string depend on the salt composition and the shape wanted which, while remaining within the same geometrical family, can be more or less thin.

Applying the dissolution laws deduced from the work of Durie and Jessen to this mining principle allows calculating the geometrical development of a cavity being leached in relation to the development of the vertical walls radius. Based on the following data : salt composition (LOGSEL), position of the fresh water and brine evacuation tubing string shoes and vertical wall progression during the various steps, the geometrical simulation computer programme developed by GAZ DE FRANCE and SOFREGAZ enables forecasting the cavity shape development and more particularly the bottom rising (Figure 4) depending on the sedimentation of the insolubles released by leaching.

3.2.3 - Cavity kinematic development simulation computer programme

Adding to this computer programme, the solution of the mass flow balance equations giving an account of the mass flow transfers within the cavity enables simulating the kinematic development of a cavity being leached.

FIGURE 4



Based upon the record of fresh water flows injected, the computer programme calculates the development over time of the cavity shape and volume, of the brine contents and flows. This computer programme is used to determine the duration of leaching periods and forecast the amount of brine produced by each cavity.

3.2.4 - Computer programme for the simultaneous leaching of several cavities

When carrying out a project of simultaneous leaching of several cavities, there is a number of restrictions, possibly incompatible with one another, which limit the field of possibilities.

Among these restrictions are the fresh water and sea water total flow rate that can be used for leaching and the brine total flow rate that can be evacuated.

Within the field of these restrictions, the following type of aims has to be reached : to have available given volumes, at a given time, on such or such cavity.

GAZ DE FRANCE and SOFREGAZ have a computer programme which helps managing such a project.

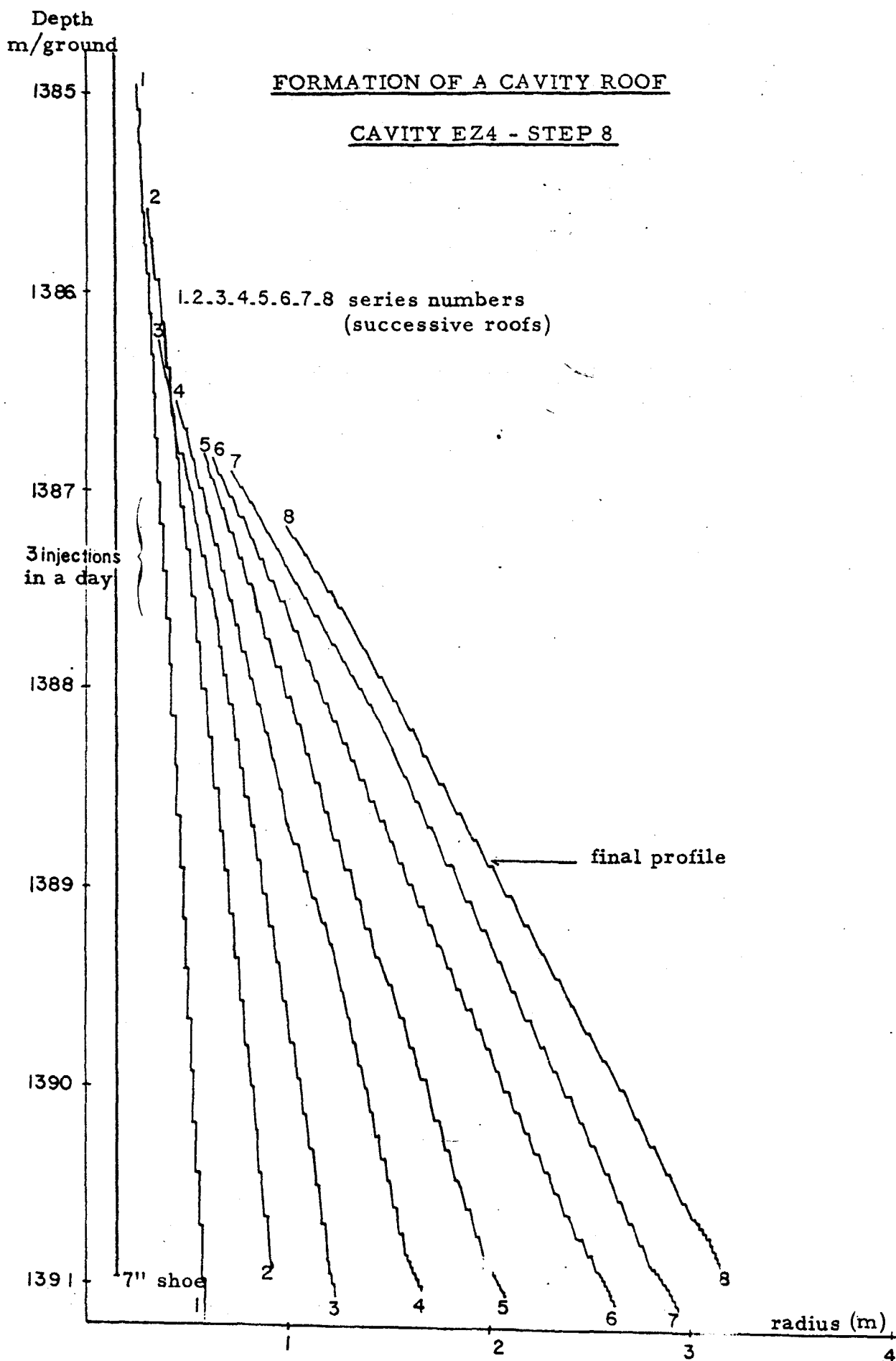
3.2.5 - Computer programme for leaching control at cavity roof

GAZ DE FRANCE has developed a technique and a computer programme allowing to obtain truncated cone-shaped cavity roofs.

This technique and the associated computer programme enable controlling the salt dissolution at the roof of cavities being leached while avoiding, in particular, an anarchic dissolution towards the top. In addition, it enables shaping the cavities in the ogival shape desired. This dissolution control at cavity roof is based on the principle of using an inert fluid (fuel is used by GAZ DE FRANCE at Tersanne and Etrez, but other fluids can be used : this fluid must be inert in relation to salt and lighter than brine).

The principle of the original method designed by GAZ DE FRANCE is the following :

Given volumes of inert fluid are injected until the inert fluid/brine interface reaches the level of the withdrawal shoe. The inert fluid then overflows and rises with the brine into the intermediate annulus. After each overflow, the inert fluid is withdrawn and a new series of injections is started in order to create a succession of truncated cones whose angle summits are increasing (Figure 5).



To implement this technique, it was necessary to set up a computer programme to calculate the quantities of inert fluid to be injected and withdrawn. This programme has two functions :

- first of all to calculate a posteriori the roof development in relation to the brine contents measured and the volumes of fuel injected and withdrawn. This part of the computer programme also includes a resetting routine which enables, on the basis of the data gathered during overflows of the inert fluid, to recalculate the past history. It is thus possible to maintain high reliability at the level of roof control over very long periods of time (more than 6 months),
- second, to calculate the volumes of inert fluid to be injected in relation to the contents forecast for the brine produced and to the roof shape. This part of the computer programme also enables calculating the volume of inert fluid to be withdrawn after each overflow.

3.3 - COMPUTER PROGRAMME RELATING TO THE OPERATION OF CAVITIES FILLED WITH GAS

In order to have a better control of the operation of cavities filled with gas and, more particularly, to make sure that the operating data are coherent, a simulation model of the thermodynamic behaviour of gas in a cavity was developed by GAZ DE FRANCE.

The corresponding computer programme numerically solves the differential equation giving account of the balance of heat quantities exchanged by gas with the ground surrounding the cavity during injection, stop or withdrawal phases.

This computer programme enables the numerical simulation of the gas pressure and temperature in the cavity with an accuracy of less than 1 %.

3.4 - COMPUTER PROGRAMME RELATING TO THE MECHANICAL BEHAVIOUR OF SALT CAVITIES

GAZ DE FRANCE having followed up for the last 10 years cavities filled with gas and carried out, more recently, in-situ testing was able to adjust two models describing the mechanical behaviour of salt.

These models are used in computer programmes implementing the method of finite elements and allowing to answer the following problems : spacing between cavities, shape and size of cavities, study of stresses at certain critical points of the cavities, such as the well casing shoe.

Besides, GAZ DE FRANCE was able to find analytic equations giving account of the mechanical behaviour of a spherical cavity isolated in an infinite massif from the Bingham model.

This model is representative and is quite satisfactory as regards to the real behaviour of salt cavities. It enabled drawing up two charts allowing answering two types of concern :

- one chart enabling the calculation of the instantaneous creep rate corresponding to a given stress (short term cavity management),
- one chart enabling the calculation of the cumulate creep rate corresponding to a succession of pressure reports over several years (long term cavity management) ; the second chart is based upon the notion of threshold pressure.

4 - ORGANIZATION OF THE CARRYING OUT AND CONTROL OF SALT CAVITY LEACHING

4.1 - GENERAL FOLLOW-UP

4.1.1 - Local follow-up

The computer programme controlling leaching at the cavity roof is used every day on each site and for each cavity. It is implemented on a mini-computer. It is the programme that enables calculating the movements (injections and/or withdrawals) of inert fluid to be carried out in the day. The corresponding volumes are then fed into a second computer which manages the injection and withdrawal operations themselves. It is the programme which, from the control room, controls the operations carried out on each platform of well being leached, by means of the equipment described in paragraph 2 above ("fuel skids").

At Etrez, the same computer is responsible for the automatic acquisition of all measurements carried out on site. An auxiliary calculation programme enables controlling at any time the consistency of the measurements carried out and thus detecting possible failures or deviations of measurement equipment or possible incidents occurring on leaching equipment (leak on a line, deterioration of a pump's characteristics, ...).

The computer programme controlling the leaching at cavity roofs also follows up the shapes of cavities being leached. Everyday, this programme enables calculating the vertical wall progression, the cavity free volume (mined volume less the volume of insolubles deposited and swelled). It also indicates the actual shape of the roof of each cavity.

4.1.2 - Follow-up centralised in Paris

In the particular case of the projects being carried out at present by GAZ DE FRANCE at Tersanne and Etrez, GAZ DE FRANCE follows up these two projects from their head office in Paris.

All the operating data used by the computer programme controlling the leaching at cavity roofs are teletransmitted every-day to Paris where they are reprocessed in order to be controlled and then filed on a magnetic file. It is therefore possible to restore the history of flows, contents and volumes, the water and brine balances, the data used for short and medium term forecasts. Once a week, the shape of each cavity is calculated by two independent methods :

- the first method consists in calculating the development of the cavity shapes on the basis of the contents measured and according to the laws of dissolution, from this calculation a first estimate of the free volume called "Durie" volume can be made,
- the second method consists in calculating a "mass balance" volume on the basis of the contents and flows measured and then in determining the development of the cavity shapes from this volume.

4.1.3 - In-situ measurements of the cavity shapes by sonar caliper survey

In-situ measurements of the cavity shapes are carried out by sonar caliper survey on average every three steps in order to check that there is a good adequation between the development forecast and the real development of the shapes, taking into account in particular the presence of insoluble layers.

These measurements are carried out by means of SOFREGAZ' sonar caliper survey unit (Figure 6).

Figure 7 gives an example of these measurements results.

4.2 - SPECIAL FOLLOW-UP OF FIRST STEP

The insoluble materials, mainly clay and anhydrite, released by leaching, deposit at the cavity bottom.

The effect of this process is to stop the dissolution of the salt layer at the cavity bottom. The height of salt massif thus neutralized rises all the faster as the sedimentation surface is small in relation to the lateral surface being dissolved. This shows how important it is therefore to control the first step, when the risk of bottom rising is the highest, and whose success conditions the rest of the leaching.

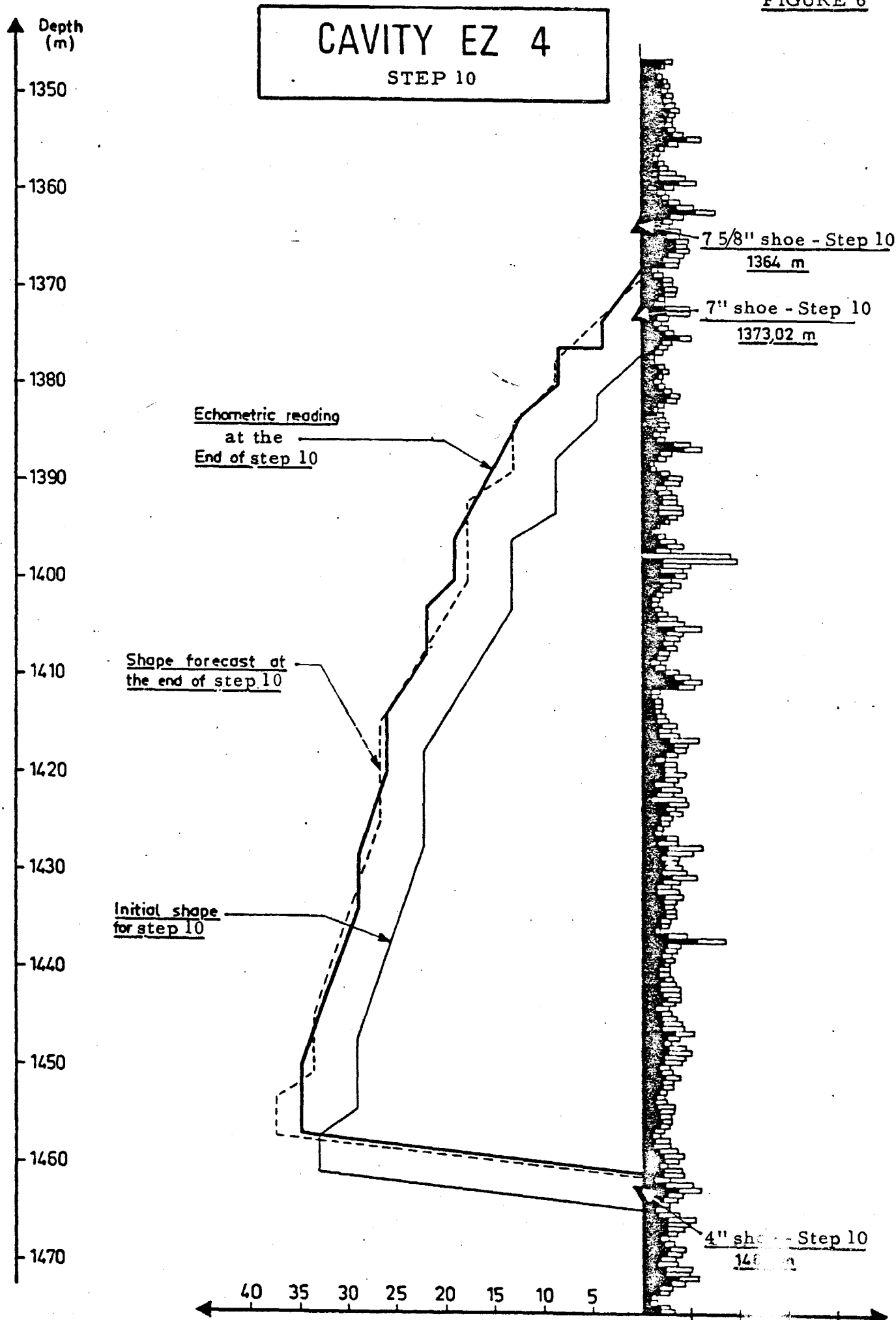
The development of the content of brine produced during the first step is simulated by the computer programme calculating the kinematic development of cavities being leached. The high sensitivity of this calculation to the parameters involved in the dissolution process enables determining the exact dissolution conditions by adjusting the measured and calculated contents of the brine produced.

In fact, during the first step, two phenomena become very important :

- on the one hand the small cavity volume enables the presence of turbulences which keep in suspension the insoluble particles which only deposit after a certain threshold or, last of all when leaching stops at the end of a step. Thanks to the computer programme mentioned above, it is possible to mark this sedimentation threshold,
- on the other hand, the presence of insoluble layers causes sometimes, particularly during the first step, the formation of superposed cavities. With this simulation programme, it is possible to show this phenomenon.

It is thus possible to forecast with accuracy the cavity shapes at the end of the first step, which enables one not to carry out, at that stage, in-situ measurements of shape by means of sonar caliper survey.

FIGURE 6



ISOMETRIC PERSPECTIVE OF CAVITY TE11

TE11

South

North

North

South

1420
1430
1440
1450
1460
1470
1480
1490
1500
1510
1520
1530
1540
1550
1560
1570
1580

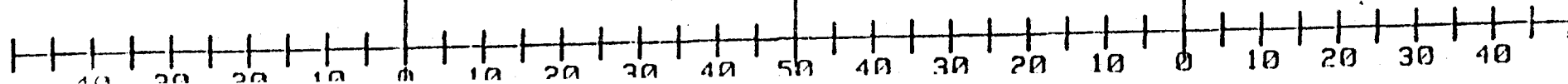


FIGURE 7

5 - MEANS IMPLEMENTED TO ENSURE THE SAFETY OF SALT CAVITIES STORAGE

The means implemented by GAZ DE FRANCE and SOFREGAZ to ensure the safety of salt cavities storages are very large.

They are mainly of two kinds :

- first of all, the development, in close cooperation with the Mining Administration, of tightness testing procedures, carried out before and after leaching of the salt cavities,
- secondly, the use of very reliable equipment and safety material for the completion of operating wells of cavities filled with gas.

5.1 - TIGHTNESS TESTS

5.1.1 - Tightness test after drilling

The major risk in an underground storage is linked with the possibility of a leak of the stored product occurring along the well casing cementation, such a leak risking to emerge at the surface and to cause damages. Therefore the greatest care must be given to cementation making and tightness controlling.

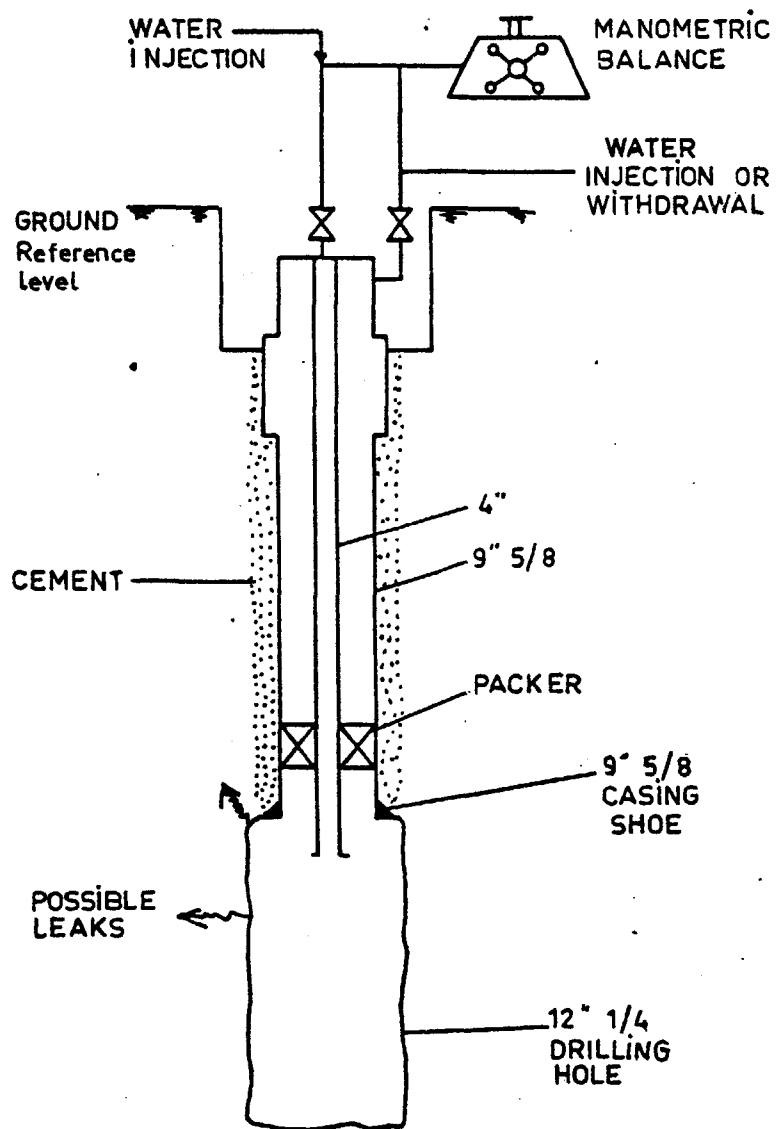
To this end, GAZ DE FRANCE has developed a tightness testing procedure carried out under pressure at least one month after the casing cementation.

This test is carried out with a special completion enabling the testing, separately, of the casing tightness and of the tightness of the unit including the casing shoe and the drilling hole (Figure 8).. The test principle consists in applying various pressure levels to the two columns and in measuring the liquid readjustment levels necessary to keep the pressures (the test fluid is saturated brine).

For the casing test, a pressure corresponding to a gradient 1.46 (ratio of the relative pressure applied to the pressure that a water column with a density of 1 would exert at the same depth) is applied to the two columns at the packer level of the test completion (the highest pressure that may be applied during leaching) ; the two pressures on both sides of the packer being equal, the risk of leak through the packer is nul, and the readjustment flow rate measured at the annulus head corresponds to the casing leak apparent flow rate.

For the casing shoe test, the pressure applied on the annulus is kept and pressure levels corresponding to gradients between 1.8 and 2 are applied to the casing shoe. The estimate of the apparent

DIAGRAM OF DEVICE FOR
TIGHTNESS TEST BEFORE LEACHING



leak flow rate at the casing shoe is given by the sum of the readjustment flows carried out to keep the pressures constant at the head of the two columns, sum from which the casing leak apparent flow rate measured during the previous test is deduced. This test is declared to be satisfactory as soon as the leak apparent flow rate remains below a few liters a day.

5.1.2 - Tightness test after leaching

After leaching, the well completion for the operation of the cavity filled with gas is installed. Generally the maximum operating pressure in the cavity at the level of the casing shoe is taken as equal to 0.9 times the test pressure before leaching. The tightness of this cemented shoe is tested again before filling the cavity with the fluid to be stored.

The principle of this new test consists in applying at the casing shoe level a pressure equal to the test pressure before leaching, using a test fluid inert in relation to salt, lighter than brine and easy for accurate volume measurements*.

Using a mass-balance method dealing with this test fluid, before and after the test is carried out, enables determining the leak apparent flow rate at the level of the cemented shoe.

In the case of cavities intended to store natural gas, this test is confirmed by a second test with gas based on the observation of the pressure developments at the head.

5.2 - COMPLETION OF WELLS FOR THE OPERATION OF CAVITIES FILLED WITH GAS

The gas completion is schematically made of two 7" and 4" concentric tubings hanged at well heads (Figure 9).

The bottom of the 7" column slides inside a packer anchored in the 9 5/8" casing ; the tightness of this unit is ensured by slip joints.

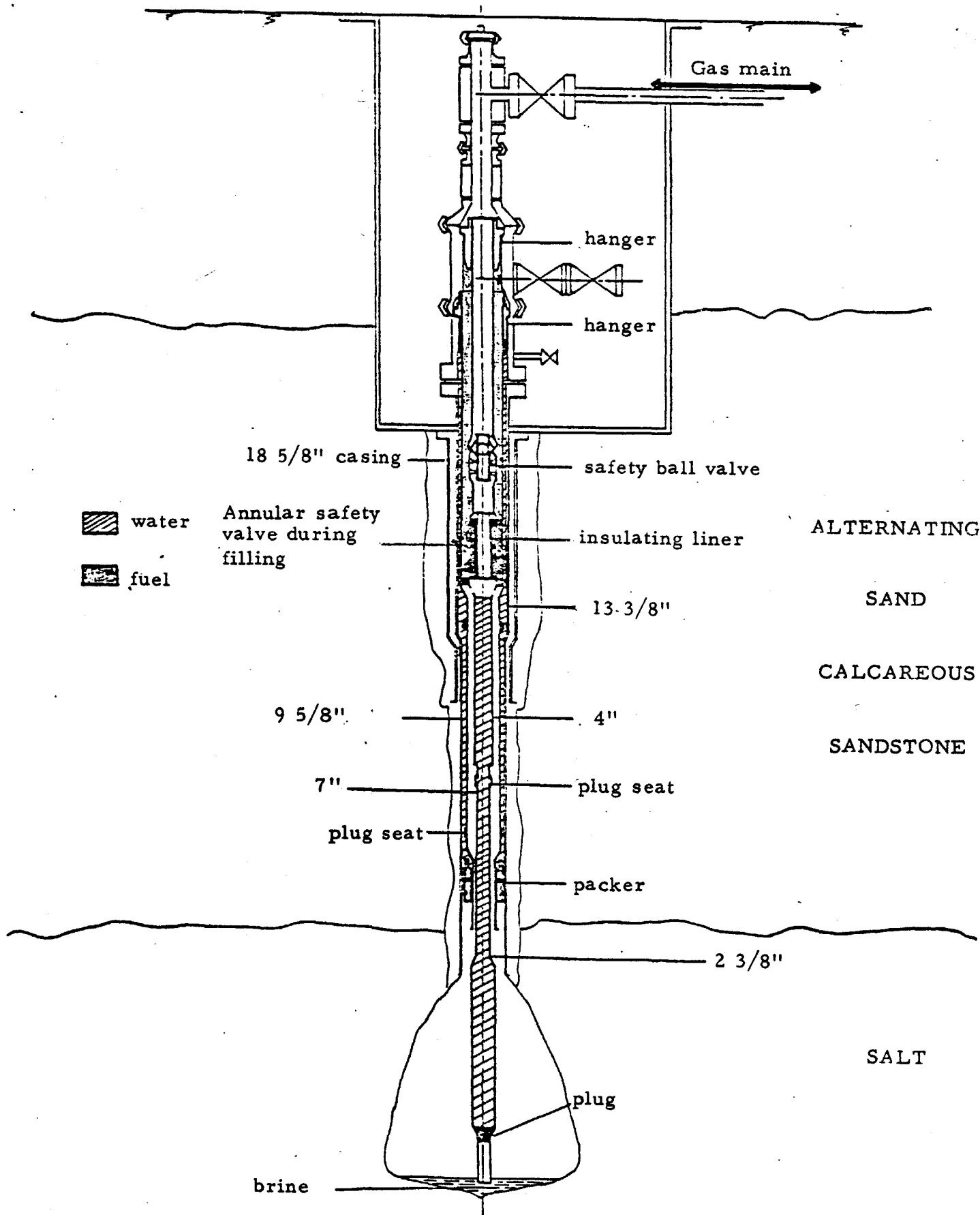
The 9 5/8" x 7" buffer annulus is filled with fresh water and is used to protect the casing cementation against the pressure and temperature variations occurring inside the production annulus. During filling of the cavity, the gas is injected through the 7" x 4" annular space and brine is sent back through the 4" column.

After filling, the cavity filled with gas is operated by the 7" x 4" annulus.

* Fuel is used by GAZ DE FRANCE at Tersanne and Etrez.

SALT CAVITY COMPLETION

Operating phase



In order to improve the well production, it is also possible to use, in addition, the 4" column to operate the stored gas.

The search for the best possible tightness for the connections between the well completion tubings led us to choose VAM thread joints with double conic shoulder, metal against metal.

During the filling of the cavity with gas, the gas injection and brine removal circuits each have underground safety valves located between 15 and 30 m under the ground surface.

For the gas circuit it is an annular safety valve (sliding side-door sleeve).

For the brine circuit, it is a ball valve.

These valves are kept open by oil pressure. In case of incident, the oil circuit is opened and these valves close under the pressure of the fluid of the circuit which they are there to close.

The incident is defined as being :

- for gas, the break down of the well head or of the surface circuit which would result in a brutal pressure variation of the surface gas due to pressure drops,
- for brine, the break down of the 4" brine rising column that would result in a brutal pressure rise, with risks of mechanical damages to the brine return line.

These safety valves are controlled by an automatic system which can be adjusted in relation to the pressure thresholds desired (low threshold for the gas circuit, high threshold for the brine circuit). This system includes a fuse plug intended to close the valves in case of fire at the surface.

These valves are also special in that they are retrievable. At the end of the gas filling, they are lifted up. Instead of the annular safety valve, a "ghost" system is installed which transforms the gas production annulus into a tubing inside space. The safety ball valve is put back in its place in its original seat : it ensures the safety on the gas circuit, after having done so on the brine circuit during the filling in.

6 - CONCLUSION

Owing to the experience they have acquired, GAZ DE FRANCE and its subsidiary SOFREGAZ have now mastered the technique of solution mining of salt cavities intended for underground storage.

Several examples of the fruit of their experience are illustrated mainly by the industrial installations of Tersanne and Etrez, but also by projects carried out abroad : in Great-Britain and Iraq.

Means of calculation were developed in order to ensure the carrying out and control of the cavity mining process and operation.

Finally efforts were made to ensure the safety of these storages.

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