

# INTEGRATION OF AN ACID PLANT INTO A URANIUM EXTRACTION PLANT

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## 1. INTRODUCTION

Early in the development of a uranium project decisions need to be made not only about the resource, but also the utilities. Many of the proposed mines are located in areas where fuel and water are not readily available and the local infrastructure may not be well developed. This poses a number of problems to prospective developers as to how to supply the required utilities to the mine and uranium processing plant.

The initial development phase of a uranium project requires a framework of decisions to be made covering all aspects of the project to allow the project to proceed. Many mines are also located in areas of limited infrastructure, where the supply of power, water, and reagents are key issues to be resolved. This paper will cover aspects related to the supply of acid to a project and will explore the issues deriving from the acid supply method.

Where uranium recovery involves acid leaching, the mechanism of supply of acid to the process plant can add another dimension to the exercise. The acid may be either imported or manufactured on site. An acid plant can supply in part power and water to the process, or purchase of acid does not provide these opportunities

If acid is manufactured on site, this can be done either by roasting pyrite or burning sulphur. The paper provides a high level review of the considerations that would be involved in making the decision.

Manufacture of acid by both routes generates a considerable amount of heat. This heat is available to be exported from the acid plant as either process steam or converted in a steam turbine to produce electrical power.

Depending on the unique circumstances of the proposed plant the acid plant can be configured such as to better integrate with regard to power, steam and also the production of desalinated water.

Consideration is also given to whether fully integrating the acid plant with the uranium processing plant is the best option or whether it is better to decouple it.

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## 2. OPTIONS TO SUPPLY ACID

There are two main ways to provide acid to a uranium extraction plant. These are:

1. Purchase acid from a manufacturer;
2. Produce acid at the Mill from  $\text{SO}_2$  generated on site either by:
  - a. Burning of sulphur in air,
  - b. Roasting of pyrite, or
  - c. Capture and processing of smelter off gases.

### 2.1 IMPORTING ACID

The following observation can be made on the supply of sulphuric acid:

- Approximately 60% of the acid produced is consumed in the fertilizer market and the bulk of the supply is produced locally on the site where fertilizer is produced;
- Only 6% of global sulphuric acid production is traded between countries;
- Only 4% is traded by sea;
- Most trade is driven by involuntary production.

Other considerations about importing acid include:

- The mass of acid is three times the mass of the sulphur required to produce the same amount of acid.
- Transport of acid is limited to a restricted number of vessels and the size of the vessels can be large, i.e. 60,000 ton which requires a larger terminal and storage at the wharf.
- Sulphur is more readily stored than acid.
- Acid, in general, is more hazardous to store and transport.

For this reason most operators prefer handling sulphur and acid production versus acid handling and storage.

### 2.2 MANUFACTURE OF ACID

In all cases manufacture of acid involves the conversion of  $\text{SO}_2$  to  $\text{SO}_3$  and dissolution of  $\text{SO}_3$  into water. The main sources of  $\text{SO}_2$  are:

- Combustion of elemental sulphur in air.
- Roasting of pyrite.
- Smelting of sulphide ores of non-ferrous metals.

Of these routes only the first two will be considered in this paper. While smelting is carried out widely and the  $\text{SO}_2$  is often captured, the actual gas handling is similar, in a broad sense, to that of the pyrite roasting route. For this reason this option does not warrant further consideration.

### 2.3 $\text{SO}_2$ FORMATION BY ROASTING OF PYRITE

The most common mineral from which  $\text{SO}_2$  can be commercially produced is pyrite which is iron sulphide ( $\text{FeS}_2$ ). In addition, sulphide ores such as sphalerite (zinc blende), and chalcopyrite (copper iron sulfide) also release  $\text{SO}_2$ .

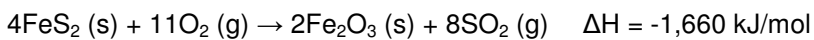
As shown in Table 1, the composition of a typical pyrite feed to a roaster can vary considerably.

**Table 1: Typical Composition of Pyrite**

Element	Units	Typical Range
Sulphur	Wt%	30 – 50
Iron	Wt%	26 – 46
Copper	Wt%	0 – 2.7
Zinc	Wt%	0 – 3.0
Arsenic	Wt%	0 – 10.0
Water	Wt%	5 - 9

### 2.3.1 Pyrite Roasting Chemistry

When roasting pyrite, the sulphides are converted into oxides according to the following summary reaction:



Approximately two kilograms of sulphur dioxide are generated per kilogram of pyrite in roasting. Depending on whether air or enriched air is used, the concentration of SO<sub>2</sub> in the roaster off gas is in the range of 8-30 vol-%. However, pyrite roasters typically do not exceed 14% SO<sub>2</sub> concentration as sintering of the pyrite can occur.

### 2.3.2 Process Technique

The most common type of roaster selected these days is the fluidised-bed based on process technology, capacity and economy. The fluidised bed roaster type selected is typically a bubbling bed in contrast to the CFD (circulating fluidised bed). One specific reason for the selecting a fluidised type is that fluidising the pyrite limits fusion of the particles. The roaster typically operates at a temperature between 600 – 1,000 °C.

The process forms a fine iron oxide residue also known as the cinder. This cinder, if pure enough can be used in steel making providing the impurities levels are low. A major concern is the arsenic level but practically this normally reduces to below 0.06% concentration in the roaster. The arsenic is volatilised which is then removed from the gas stream in the wet gas cleaning process prior to entering the acid plant.

Gas conditioning of the process gas leaving the roaster is completed in the section of the plant commonly referred to as the Gas Cleaning Section divided into two sections Hot and Wet. The Hot Gas Cleaning Section generally comprises a Waste Heat Boiler to remove excess heat in the gases, Cyclones and a Hot Electrostatic Precipitator to remove larger dust particles. Wet scrubbers, such as a Reverse Jet scrubber(s), for further particulate and halides removal (acid plant catalyst poisoning) and adiabatic cooling, a Gas Cooling Tower for further cooling and Wet Electrostatic Precipitators for the finer mist removal.

The process gases are saturated with moisture which must be removed prior to contact with the catalyst. This is accomplished in the Drying Tower.

Typical outputs from a pyrite roaster are shown in Table 2.

**Table 2: Typical Product Gas from a Pyrite Roaster**

	Units	Value
SO <sub>2</sub>	8 - 10	Vol%
O <sub>2</sub>	8 – 11	Vol%
Energy	~4,500	MJ/ton H <sub>2</sub> SO <sub>4</sub>
Conversion	99,4 – 99,6	%

**2.4 SO<sub>2</sub> FORMATION BY BURNING ELEMENTAL SULPHUR**

**2.4.1 Sulphur Burning Chemistry**

When sulphur is burnt in air the SO<sub>2</sub> is produced according to the following summary reaction:



Using air, it is technically possible to produce 20.5%vol assuming 100% conversion, however combustion temperature limits the maximum concentration of SO<sub>2</sub> to around 12%. In reality, in order to get complete sulphur combustion excess air is required and for later conversion a fairly equal ratio of SO<sub>2</sub> to O<sub>2</sub> is also required.

**2.4.2 Process Technique**

The production of SO<sub>2</sub> from elemental sulphur has been done for centuries. The elemental solid sulphur is melted in a pit. It is pumped into a sulphur burner where it is sprayed into a combustion chamber with air where it is oxidised into SO<sub>2</sub>.

**Table 3: Typical Product Gas Composition from a Sulphur Burner**

	Units	Value
SO <sub>2</sub>	6 - 12	Vol%
O <sub>2</sub>	9 - 15	Vol%
Energy	5,400	MJ/ton H <sub>2</sub> SO <sub>4</sub>
Conversion	99,2 – 99,6	%

Typical outputs from a sulphur burner are shown in Table 3.

**2.4.3 Acid Plant**

Most of the acid plants built in modern times are of the double contact double absorption type. These have two absorption towers which increase the recovery of the SO<sub>3</sub> compared with the single contact single absorption type plants, but more importantly meet ever increasing environmental emission limits. A brief comparison between the three types is shown in Table 4.

**Table 4: Comparison Between the main Three Types of Sulphuric Acid Plants**

Technology	SO <sub>2</sub> Fed in Gas	Conversion [%]	Comments
Single Contact, Single Absorption	3 – 10 3 - 6	97 - 98.5 97.5- 98.5	Will not meet the environmental discharge limits for a conventional sulphuric acid plant.
Double Contact, Double Absorption	6 – 12	99.7+	Most commonly technology for purpose built acid plants.

Typically in an acid plant, an SO<sub>2</sub> content below 6.5%vol in the feed to the first pass of the converter will not release enough energy for the plant to be self-supporting and supplementary heating will be required.

### 3. COMPARISON BETWEEN SULPHUR BURNING AND PYRITE ROASTING

As mentioned above this paper considers two principle routes by which sulphuric acid can be produced. In Table 5 a comparison is made between the two options for the same plant capacity.

**Table 5: Comparison between a Pyrite Roasting and Sulphur Burning Acid Plant**

**Basis: 2,000 t/d H<sub>2</sub>SO<sub>4</sub>, USA delivery, 2009**

	UNITS	FEED TYPE	
		PYRITE	SULPHUR
CAPEX	US\$ mill	\$ 150	\$ 90
Direct Production Cost			
Feedstock	US\$/ ton of acid	\$ 14.50	16.70
Power	US\$/ ton of acid	- \$ 10.80	- \$ 12.90
Utilities	US\$/ ton of acid	\$ 7.00	\$ 3.90
Labour	US\$/ ton of acid	\$ 4.50	\$ 2.70
Maintenance	US\$/ ton of acid	\$ 6.40	\$ 3.90
<b>TOTAL</b>	US\$/ ton of acid	\$ 21.60	\$ 14.30

Ref: Mutler, W.V., Warren G., " Pyrites vs Sulphur", Proceedings on Pyrometallurgy of Nickel & Cobalt, The Canadian Institute of Mining and Metallurgy, August 23, 2009

Table 5 clearly shows that sulphur burning has a considerably lower CAPEX and except for the marginally higher cost for sulphur, also has a lower operating/ production cost. The potential disposal cost of the iron sulphide residue from the pyrite process has been omitted. The assumed cost for delivered pyrite is US\$ 20/t with a sulphur content of 46% and \$50/t for sulphur.

As a result of the higher CAPEX and OPEX, sulphuric acid is usually more cost effective being manufactured from elemental sulphur. In the section below a brief history of sulphur supply to the Rössing uranium mine is given.

#### 3.1 HISTORY OF ACID SUPPLY TO RÖSSING MINE

In 1976, Rössing commissioned a pyrite roasting sulphuric acid plant to meet the mine's requirements for sulphuric acid. The pyrite was sourced from the Otjihase Copper Mine. However, in 1997 pyrite was no longer available from the mine and the plant was converted to a sulphur burning plant. The sulphuric acid plant continued operation until 2000 at which point it was mothballed due to the price of imported sulphuric acid falling below the on-site manufactured cost. The Rössing operations began importing and continue to import sulphuric acid from Walvis Bay.

Rössing Uranium indicated in 2008 that they may expand the existing processing plants or use heap-leaching technology to boost output. As part of this potential expansion, Rössing Uranium was granted environmental clearance for, amongst other things, a sulphuric acid manufacturing plant with associated on-site sulphur storage transported from the Port of Walvis Bay. Trials for the heap leaching operation are reportedly underway and a decision on the investment is expected during Q2 2009.

#### 3.2 SUMMARY

In most cases the sulphur burning option is preferred due to the lower capital cost, the lower maintenance, higher availability and not wishing to deal with the cinder waste. In cases where obtaining sulphur is problematic from a logistics point of view and pyrite is locally available, a pyrite roasting acid plant may be a more cost effective option.

## 4. HEAT GENERATION FROM A SULPHUR BURNING ACID PLANT

### 4.1 SO<sub>2</sub> CONVERSION AND ABSORPTION CHEMISTRY

SO<sub>2</sub> conversion and the SO<sub>3</sub> absorption reaction follow the following formulae:



Overall, approximately 5.4 GJ is liberated per ton of acid (100%) as a result of the burning of sulphur, the conversion to SO<sub>3</sub> and the absorption into acid.

### 4.2 ACID PLANT DESCRIPTION

A simplified flowsheet for a Double Contact/ Double Absorption Acid Plant is shown in Figure 1.

Molten sulphur is combusted in the Sulphur burner to produce SO<sub>2</sub>. This reaction is highly exothermic and a large portion of the heat produced is recovered in the waste heat boiler before the SO<sub>2</sub> gas is introduced into the first pass of the Converter. The gas makes three passes through the Converter with heat exchange (cooling of the gas) occurring before each of the successive passes. The gas which is now predominately SO<sub>3</sub> passes through the Interpass Absorption Tower where the bulk of the SO<sub>3</sub> is absorbed into acid. The remaining SO<sub>3</sub> and unreacted SO<sub>2</sub> are returned to the fourth and final pass in the Converter. The gas from the final pass after cooling is passed through the Final Tower where essentially all the SO<sub>3</sub> is absorbed. The waste gas is vented to atmosphere.

The acid from the Interpass and Final Towers is cooled in the Acid Coolers and the Product Acid Cooler prior to being pumped to storage. Cooling of the acid is normally by shell and tube and/or plate and frame heat exchangers with water used as the cooling medium.

Steam raised in the Waste Heat Boiler is typically superheated prior to being exported. This steam is available for process heating, generation of power or a combination of the two. This paper discusses how the heat available can best be integrated (used) within the uranium plant.

Heat is generated in the Sulphur Burner/ Combustion Chamber, the Converter, the Interpass Tower and the Final Tower. The relative amounts of heat generated in each unit are shown in the Sankey Diagram Figure 2.

The heat from the Waste Heat Boiler and Converter typically is 70% of the total heat generated and is normally recovered as HP steam. Mostly commonly, either 60 Barg or 40 Barg steam is produced. 40 Barg steam pressures typically allow the use of carbon steel for piping and equipment. However, at 60 Barg piping and some equipment may require fabrication in exotic alloys such as chrome molybdenum. The higher the temperature of the steam, the higher is the thermal efficiency which has led a number of clients to investigate pressures in excess of 60 Barg. Currently SNC-Lavalin Fenaco is undertaking a study for an acid plant which will produce 150 Barg steam to achieve higher efficiencies in energy recovery. The trade off is obviously the higher capital cost of the materials of construction.

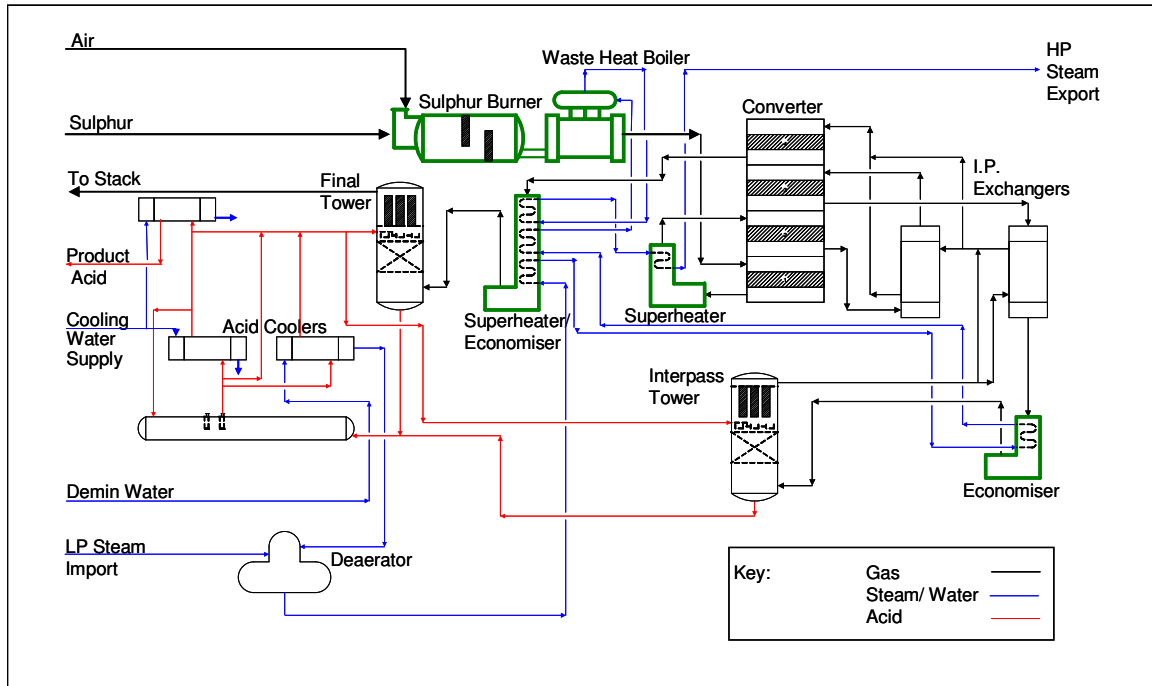


Figure 1: Typical Double Contact/ Double Absorption Acid Plant Flowsheet

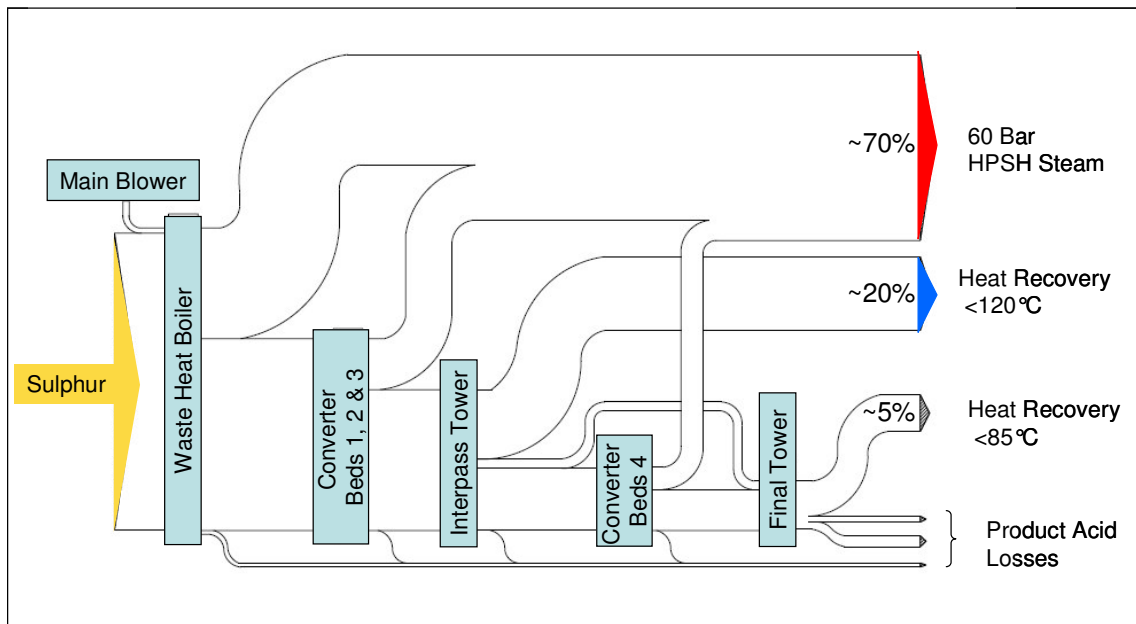


Figure 2: Sankey Energy Output Diagram for a Double Contact Acid Plant

Roughly 20% of the heat is generated in the Interpass Absorption Tower. The temperature of the heat produced is typically less than 120° and is not recovered but lost to the cooling water circuit. Similarly around 5% of the heat is generated in the Final Absorption Tower. The heat is typically below 85° and is not recovered.

Roughly 5% of the heat generated is lost from the system and in the product acid.

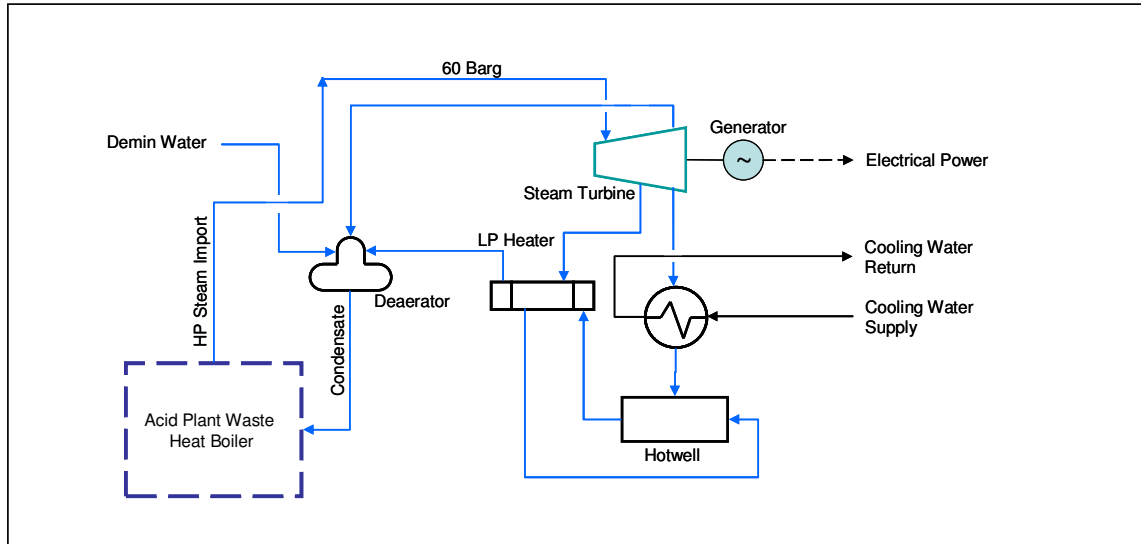


**4.3 COGENERATION PLANT DESCRIPTION**

A typical flowsheet for an acid plant cogeneration plant with a condensing steam turbine is shown in Figure 3. HPSH Steam from the plant is fed to the Steam Turbine. The exhaust from the turbine is typically around 20 – 30 kPaa and contains up to 12% moisture.

In the flowsheet there are two steam extraction points with the steam used to pre-heat the boiler feed water and, in the case of a sulphur burning plant, LP steam is supplied to the heating system for sulphur melting, storage and filtration (not shown). This increases the overall efficiency of the plant.

Cooling water is supplied to the condenser and typically the heat is rejected in a cooling tower.



**Figure 3: Schematic of a Cogeneration Cycle for an Acid Plant**

**4.4 NET EXPORT OF POWER**

In a basic acid plant the amount of net power exported is shown below in the Table 6 as a function of the amount of acid consumed per ton of ore processed.

**Table 6: Net Export of Power versus Acid Consumption**

ACID CONSUMPTION [kg acid/ton ore]	PLANT CAPACITY [ton acid/d]	HP Steam Produced [61 Bar @ 486C]		
		[ton steam/h]	Gross Power [MW]	Nett Power [MW]
20	967	50	13	9
40	1,934	100	26	18
60	2,901	150	39	27
80	3,868	200	52	36
100	4,835	250	65	45
120	5,802	300	78	54
140	6,769	350	91	63

Notes: U<sub>3</sub>O<sub>8</sub> produced assumed to be 3,000 ton/annum;  
 Uranium content of the ore assumed to be 200 ppm;  
 Ore processed is 15 million tons per annum;  
 Plant availability assumed to be 85%;

Steam turbine efficiency assumed to be 0.18 ton of steam / MW; and

Heat generated from acid absorption not recovered.

In this configuration a condensing steam turbine would be used. To improve the efficiency of the steam cycle, intermediate pressure (IP) steam and low pressure steam (LP) would be extracted from the turbine and used to preheat the boiler feed water (BFW), condensate, and in the Deaerator respectively.

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## 5. INTEGRATION OPTIONS

There are a number of ways to integrate an acid plant into a uranium processing plant. Considerations include:

- Obtaining the required steam to power ratio;
- Recovery of the heat liberated in the Interpass Tower (installation of a HRS);
- Use of the LP steam from the stream turbine exhaust for desalination of saline/seawater; and
- Decoupling of the acid plant from the Uranium Processing Plant

### 5.1 OBTAINING THE REQUIRED STEAM TO POWER RATIO

Depending on a number of unique parameters for each plant the requirements for steam and electrical power will be different. In plants which require elevated temperature in leaching, additional steam will be required which may be directly injected into the vessel or used as a heat exchange medium to heat the slurry.

There are acid plants operating which make more money from the sale of power than they do from the sale of acid.

In this section some of the potential users of steam are explored which can influence the ratio of steam to electrical power produced.

#### 5.1.1 Uses of IP Steam

LP steam in the acid plant for sulphur melting. Sulphur at room temperature is solid. In order to burn the sulphur it is melted and sprayed into the combustion chamber. The sulphur temperature is between 140 - 150°C which is the range of temperatures where the viscosity of the sulphur is low enough to be sprayed.

Heat is required not only to melt the sulphur but also to trace the piping and heating the sulphur filters. The total amount of steam required is 0.5 t of 5 Bar steam per ton of sulphur.

Using steam in preference to electrical power is considerably more efficient as the latent heat is utilised.

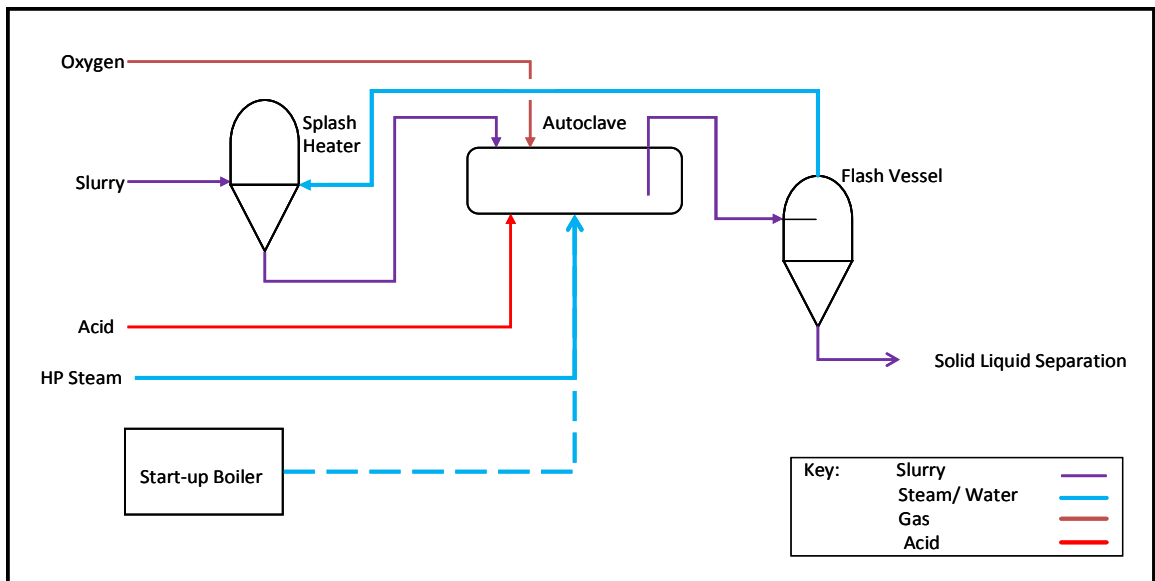
#### 5.1.2 Uses of HPSH Steam

- HPSH steam injection in autoclaves.

Autoclave should be considered at the scoping stage of the project. Although the autoclave can be relatively expensive, when considered overall it may be economic especially in cases where:

1. The kinetics are increased reducing the residence time required considerably compared to atmospheric leaching. The cost of an autoclave compared with the cost of a number of large tanks, may be less.
2. Recovery of uranium may be higher in an autoclave.
3. If there is sulphur, such as pyrite, in the feed, this will be converted to sulphuric acid. This could potentially remove the requirement for an acid plant. Secondly the exothermic reaction will provide considerable heat and reduce the steam requirement.

An example of this is Dominion Reefs Plant which had a two stage leach. An initial atmospheric leach followed by an oxygen pressure leach. The pressure leach was designed to operate at a temperature of around 180°C and a pressure of 14 Barg. Flash steam from the Flash Vessel is used to preheat the feed and the reaction of sulphur to sulphuric acid produces considerable amount of heat. Steam is injected into autoclave to supplement the heat input to reach the operating temperature. This is shown in Figure 4.



**Figure 4: Schematic of Direct Steam Heating in an Autoclave**

At Dominion Reefs the steam was produced from a standalone boiler, but the HP steam could be sourced from the acid plant as shown in Figure 4. Regardless of the source of the steam, a standalone boiler would be required in order to start up the plant or to keep the uranium mill on line in the event of operational problems in the acid plant.

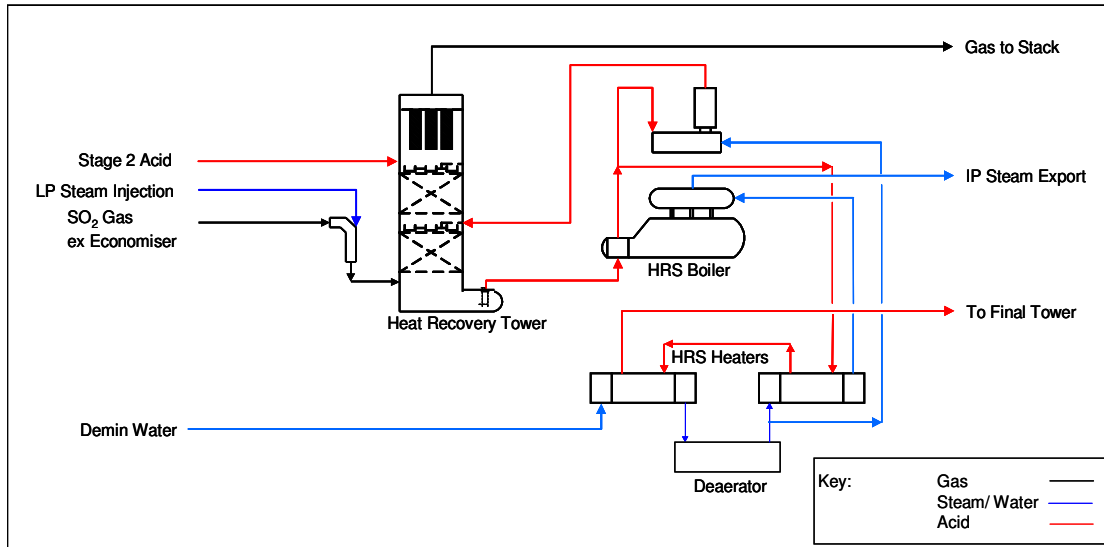
- Use HPSH steam in the acid plant to run a steam turbine driven main blower.

The power consumed by the main blower is typically 1.5% of the overall power energy and is normally electrically powered. An option is to power the main blower by a steam turbine. This is not commonly done for two reasons. The size of the steam turbine is typically in the region of 5 – 6 MW and the efficiency is lower and as a result the energy savings is not that attractive. Secondly, if the blower is steam driven; at start-up an auxiliary boiler is required to produce steam which adds complexity and it takes considerably longer to start the plant. One option is to install a small electrically power blower in parallel with the main blower for start-up.

## 5.2 INSTALLATION OF A HEAT RECOVERY SYSTEM (HRS)

As shown in the Sankey Diagram, Figure 2, the heat recovered from the Intermediate Tower is typically not recovered as energy but lost into the cooling water circuit as the heat is not available at high enough temperature to be recovered as IP (intermediate pressure) steam. One option technology which is available for the recovery of the heat from the Intermediate Tower is HRS, a patented technology invented by MECS.

The heat recovery system described in this section increases the heat recovery from 70% to around 90%. The MECS technology involves replacing the Intermediate Tower with a HRS Tower and associated equipment as shown in Figure 4.

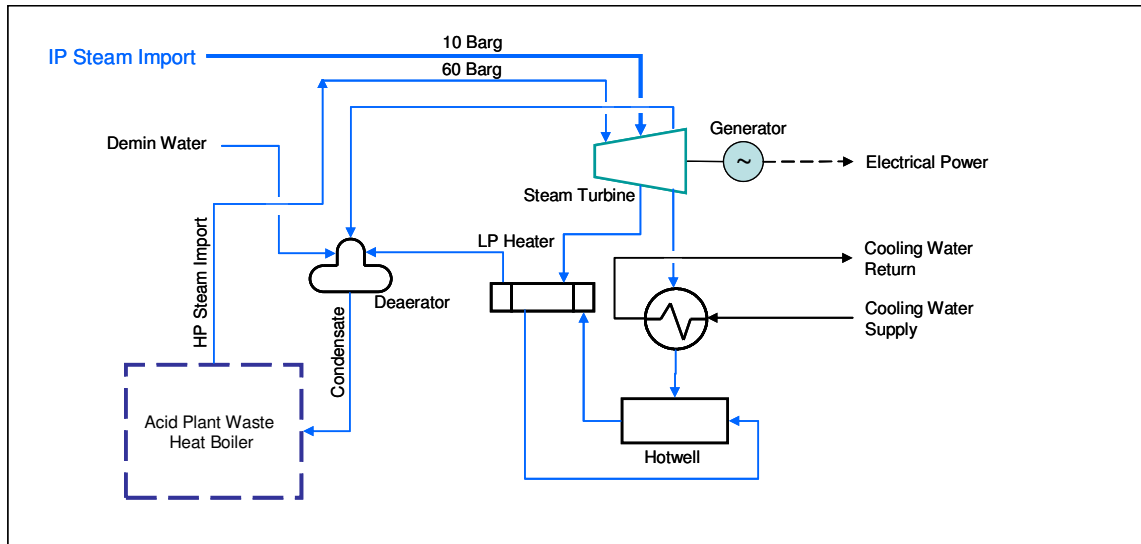


**Figure 5: The MECS Heat Recovery System**

The feed to the HRS is SO<sub>3</sub> gas from the IP Heater/ Economiser which is heated by the direct injection of steam raising it to around 250°C. The hot gas is introduced at the bottom of the Heat Recovery Tower. As the hot gas passes up the tower SO<sub>3</sub> is absorbed into the acid flowing down the tower. The absorption of the SO<sub>3</sub> into the acid generates additional heat and raises the temperature of the acid to around 230°C at the bottom of the tower.

The hot acid from the HRS Tower is pumped through the HRS boiler in which up to 10 Barg steam (IP Steam) may be raised. This additional steam can be introduced into the steam turbine through an admission nozzle as shown in Figure 5.

The acid strength and temperature in the HRS circuit are closely controlled in order to prevent rapid corrosion of the vessels and piping.



**Figure 6: Schematic showing an option to integrate the IP steam into the cogeneration cycle**

The cost of an HRS whether installed in a new plant or retrofitted varies markedly from project to project. As a rule of thumb, if the cost of electrical power is US\$ 0.06 or higher, the plant payback will be less than 3 years. Secondly the HRS will produce 0.5 t of 10 Bar steam per ton of acid produced. This is equivalent to a 40% increase in steam production.

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### 5.3 USING WASTE HEAT FOR A DESALINATION PLANT

#### 5.3.1 Background

There are three main groups of technologies that can be used to separate salt from water. These are:

1. Thermal processes in which the water is converted into steam and recovered by condensation;
2. Physical separation generally with a membrane; and
3. Chemical types such as ion exchange and liquid-liquid separation.

The waste heat from the cogeneration cycle can be used to produce desalinated water. The waste heat can either be obtained from the exhaust steam from the steam turbine but also from cooling of acid. Ravensthorpe Nickel used the waste heat from the acid cooling to produce desalinated water.

When the source water is seawater thermal processes are typically used. However if the salt content of the water is low, such as brackish water, an alternative is to explore physical separation with the electrical power being supplied by the steam turbine.

Thermal processes typically have an energy requirement around 120 – 290 kJ/kg using steam compared with 15 – 30 kJ/kg for seawater Reverse Osmosis (RO). Assuming that the efficiency for the conversion of steam to electrical power is 35%, the equivalent energy requirements for RO would be 45 – 90 kJ/kg.

Other factors which need to be considered in comparing the options are the volume of seawater that needs to be pumped and treated, the recovery efficiency, and the volume of brine which needs to be pumped back to the coast. Depending on the specific nature of the project, RO may be cheaper than a thermal option.

For brackish water RO can be as low as the electrical energy usage can be as low as 9 kJ/kg. This would be equivalent to around 27 kJ/kg based on steam usage which is clearly lower than any thermal process can achieve.

In summary recent improvements in technology have seen RO increasingly used in desalination applications.

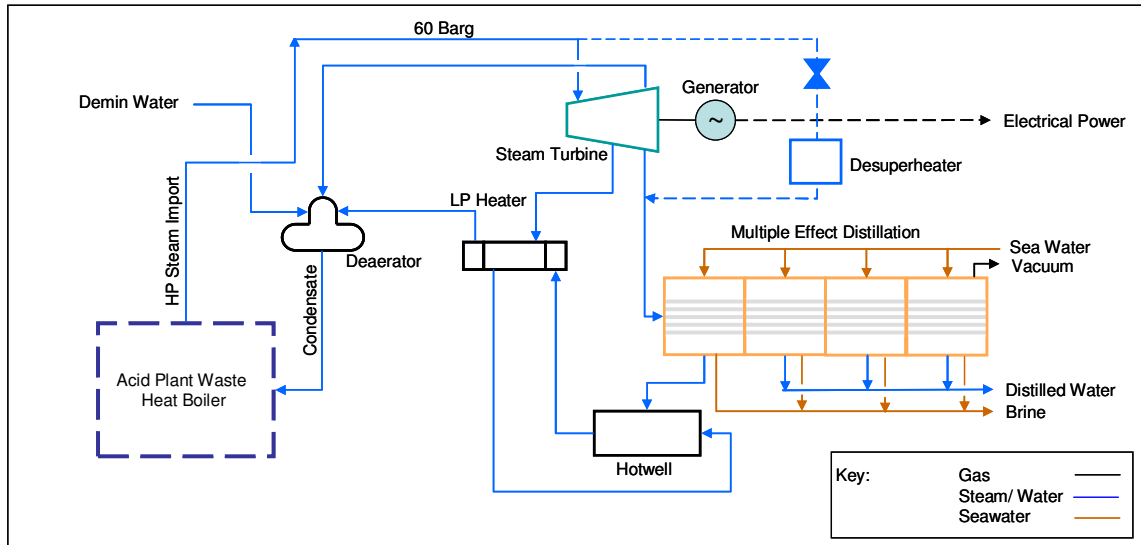
#### 5.3.2 MED Process Description

There are two main types of desalination available which are based on thermal technology. These are the MED (multiple effect distillation) and the MSF (multiple stage flash). In addition, MED can be divided into the low temperature and high temperature types.

Most of the original plants were of the MED type but these suffered from high scaling and as a result the availability of these plants was low. Mainly for this reason there was a shift away from MED to MSF.

For the purposes of this presentation it is assumed that a MED is installed.

The basic flow diagram is shown in Figure 6.



**Figure 7: Schematic of a Cogeneration cycle including the installation of a MED**

LP exhaust steam from the condensing turbine or waste heat from acid cooling is fed into the first effect of the MED, tubeside. Seawater is sprayed over the top of the tube bundle and part of the seawater is vapourised. The vapour passes into the second stage while the remaining seawater, brine, collects at the bottom of the effect and is combined with the brine from the other effects and is typically returned to the ocean.

The vapour from the first effect passes through to the tubeside of the second effect where it vapourises part of the seawater which is sprayed over the tube bundle. The vapour condenses and is recovered as product, desalinated water.

In the final effect the condensate is condensed with seawater. Part is recovered in preheating of the feed seawater, but the bulk is lost in the seawater which is only used for cooling.

Assuming that there are 8 effects, the specific heat consumption is around 80 kcal/kg.

#### 5.4 DECOUPLING OF THE ACID PLANT

Consideration needs to be given to how integrated the acid plant should be with the Uranium Processing Plant. If the Uranium Processing Plant is totally reliant on the acid plant to produce either power and or steam, any downtime of the acid plant will result in the rest of the plant being down.

For this reason, some developers prefer that the acid plant only produce electrical power. The backup systems required to replace the lost power should the acid plant be down are relatively simple and straightforward (e.g. auxiliary boilers or standby diesel generators). There are additional benefits to developing power from an acid plant, especially if the power plant can easily be connected to a local power grid. In extreme situations, the developer may find it more economical to supply power than uranium.

## 6. SUMMARY

In this paper the design issues and decision which need to be made to integrate a sulphuric acid plant into a uranium extraction plant have been discussed.

The first decision that needs to be made is whether to import the acid or to manufacture the acid on site. In general most plant operators prefer to handle elemental sulphur than acid. This is due to the costs of storing acid, the dangers and other logistic issues.

Most of the acid manufactured on site is from elemental sulphur. It can be from pyrite but most plants use elemental sulphur as the capital cost is lower, the availability of a sulphur burning plant is higher, there is less maintenance and there are no problems with the disposal of iron sulphide cinder.

The manufacture of acid produces significant amounts of heat. This heat is in excess of the power requirements for the acid plant and is available for export to the uranium extraction plant either as steam or electrical power.

Depending on the process heating requirements of the plant, the availability of water, proximity of a local power grid and other factors, the acid plant can be configured to better integrate with the requirements of the uranium extraction plant. In this paper the integration options discussed are:

1. Installation of a HRS;
2. Obtaining the required steam to power ratio;
3. Producing desalinated water either from turbine exhaust or acid cooling; and
4. Considering decoupling of the acid plant from the uranium processing plant.

In each new uranium plant, the requirements are unique and the integration needs to be tailored in order to achieve an optimum design.