Aluminium Fluoride (AlF_3) – A market striving towards equilibrium

China dominates the production of AlF_3, an essential commodity required for aluminium pot lines. Its low cost structure means that it is well set to meet over 50% of world market demand in 2010 likely causing the closure of some 70kt of high cost western AlF_3 production. **By Michael Reynolds***

The electrolytic bath in an aluminium electrolysis cell contains 80% synthetic cryolite (AlF_3). Operating losses of fluorine from the cell are made up almost exclusively by the addition of further AlF_3.

The recent global economic crisis brought to the forefront and accelerated trends in the AlF_3 market which have been evident for some time. These trends are the result of basic economics.

It has become even more apparent that aluminium smelting should be carried out where the producer has access to energy sources which are abundant and relatively inexpensive. Similarly AlF_3, which depends more on raw materials than energy, should be manufactured where the raw materials are abundantly available at a reasonable cost. It does not matter where the customers for aluminium or AlF_3 are located but it does matter where the energy and raw materials are located.

The global economic crisis has resulted in an acceleration in the curtailment, and even closure, of aluminium smelting capacity in Europe and North America, a scenario very similar to the Japanese pattern of 20 years ago where now there are no major primary smelters operating. Instead new smelters are sprouting up in the energy rich Middle East, in Oman, Abu Dhabi, Qatar, Iran and Saudi Arabia.

Contemporaneously AlF_3 production in the West has been curtailed and even shut down; witness the closure of plants in the USA (Alcoa) and Brazil (Nitroquimica) as well as the curtailment of production in Mexico (IQM).

Why has this happened? What's going to happen next? When will the AlF_3 market stabilise and reach equilibrium, and what will this new market look like? The answer to many of these questions is China.

A profitable producer of AlF_3 must have certain attributes:

A – Access to low cost raw materials, in particular fluorspar, and preferably have them under its control or ownership;
B – Have efficient processing technology and relatively modern or at least a well maintained plant;

DFD's AlF3 plant showing the HF kiln in the foreground and HF distillation plant in background

Producer	2007 Capacity	2010 Capacity
Rio Tinto Alcan (Canada)	60	60
Alcoa (USA)	60	Closed
IQM (Mexico)	45	10 (effective)
Mexichem Fluor (Mexico)	Not existing	60
Nitroquimica (Brazil)	15	Closed
Alufluor (Sweden)	23	23
Noralf (Norway)	40	40
DDF (Spain)	20	20
ICF (Tunisia)	45	45
Fluorsid (Italy)	65	80
Total	**373**	**338**

Table 1 Major Western producers of AlF_3 (kt)

C – Have a stable portfolio of customers;
D – Possess financial strength; and
E – Be a low operating cost producer.

Alcoa and Nitroquimica which closed and IQM which reduced production were each missing more than one of these elements.

– Alcoa, lacked A and E;
– Nitroquimica lacked B and E;
– IQM lacked C and D.

The question to ask is which remaining producers is next to close or drastically reduce production? **Table 1** is a summary of the main Western exporting producers.

These remaining non Chinese producers not only have to compete against Chinese producers (to be examined later) but also against Mexichem Fluor, a new competitor in Mexico which started production in late 2009.

Mexichem Fluor has the advantage of a good position in attributes A, B and D, although it still lacks a portfolio of customers. The overall operating costs of Mexichem are unknown. However, as it is a US dollar oriented economy, it presently has an important advantage compared to the other predominantly Euro based producers.

The remaining Western producers who are potentially at risk of curtailment or closure in the future number six:

– Rio Tinto Alcan, Noralf, DDF, Fluorsid, Alufluor, and ICF.

Each of these has strengths and weaknesses. All have been in the market for many years, have stable customers (so far) and presumably efficient processing. The weaknesses of each are:

* Director of Printemps Ltd, [export sales agent for Do-Fluoride Chemicals Co Ltd (DFD)],
Tel +3902460141 Fax +3902437677 e-mail: msreynolds@msreynolds.com
Based on a presentation to the 9th Industrial Minerals Fluorspar conference, Valencia, Spain, November 17-19, 2009

1 - Chinese ex mine price	180
2 - Freight to port, FOB charges	25
3 - Traders export margin and financing	20
4 - Export licence	45
5 - 15% export tax	30*
FOB China Price	300
6 - Ocean freight to Rotterdam	40
CIF Rotterdam	340

**Starting in 2010 the export licence has been removed but mining has been restricted*

Table 2 Factors backing up the additional export price of Chinese fluorspar (US$/t)

- No captive fluorspar: Rio Tinto Alcan, Fluorsid, Noralf, ICF
- No captive or low cost sulphuric acid: Rio Tinto Alcan
- Higher operating costs due to Euro based economy: Fluorsid, Alufluor, Noralf, DDF.

In addition, Alufluor has a potential raw material supply risk. It depends on inexpensive H2SiF6 which is a by-product of phosphoric acid production. If and when those plants in Europe producing phosphate fertilisers close, its source of H2SiF6 could become prohibitively expensive.

All six producers suffer from potential market attrition due to competition from Mexichem Fluor and Chinese producers.

AlF3 is a simple, but brutal commodity. The majority of its total cost, (70%) is composed of energy and raw materials. The remaining 30% is made up of labour (10% including maintenance), general overheads, maintenance materials (3 - 5%), depreciation, financing charges, and hopefully some profit.

This 30% is a fixed cost except for depreciation; labour in the West is not a variable cost.

The profitability of the business is extremely volume dependent. If a plant runs at 80 – 90% capacity it will thrive or at least survive (depending on sale price). If utilisation falls to 60% or below for more than one or two years there is a serious risk of closure.

The market demand today is insufficient to satisfy all producers, therefore, one or more participants will be forced to close.

Ostensibly the Chinese are to blame for this. This is true but not for the first reason which may come to mind, which is the low cost of Chinese labour. The real answer is: China has fluorspar. Of the about 5Mt of fluorspar mined every year, China extracts 3Mt or 60%. On this basis alone China should produce 60% of the world's AlF3. It actually will soon produce more than 60% because China also manufactures over 30% of the world's primary aluminium metal.

The other major fluorspar producing countries in the world and therefore potential AlF_3 producers are:

- Mexico which now has Mexichem Fluor and IQM;
- South Africa which is planning to build a plant;
- Namibia, but this has no plans to build a plant;
- Spain which has DDF.

Fluorspar is important as it requires 1.5t of fluorspar to produce a tonne of AlF_3.

Province	Number of Plants	Wet capacity Name Plate	Wet capacity Effective	Dry capacity Name Plate	Dry capacity Effective	Total AlF_3 capacity Name Plate	Total AlF_3 capacity Effective
Henan	3	35	5	260	210	295	215
Shandong	7	45	15	115	100	160	115
Gansu	2	10	0	50	15	60	15
Hunan	2	90	0	180	120	270	120
Ningxia Municipality	1			110	70	110	70
Liaoning	1	5	0	30	0	35	0
Yunnan	1	5	5			5	5
Jiangsu	1	5	0			5	0
Guangxi	1	21	5	15	0	36	5
Fujian	1			30	9	30	9
Hubei	1	12	0			12	0
Guizhou	1	14	0			14	0
Anhui	1			40	6	40	6
Totals	**23**						
Name plate Capacity		**242**		**830**		**1072**	
Effective Capacity			**30**		**530**		**560**

Table 3 Chinese AlF_3 plants capacities and expected outputs in 2010 (kt)

China price setter

China still sets the world price for fluorspar. China sells fluorspar internationally at a price CFR Rotterdam of about US$340/t.

However, the domestic Chinese price for fluorspar is only $180/t, the difference is made up of the factors listed in **Table 2**.

Therefore, in 2009, the difference in cost of fluorspar per tonne of AlF_3 for a Chinese AlF_3 producer versus a non-Chinese Western producer is:

China	180 x 1.5 =	$270/t
Western	340 x 1.5 =	$510/t
Difference		$240/t AlF_3

$240/t on a product costing less than $1000/t on a CFR basis is 24% in a commodity business where one struggles to earn 5%.

To make one tonne of AlF_3 it requires 4.3t of raw materials made up of:

1.5t of fluorspar
1.0t of alumina hydrate
1.8t of sulphuric acid.

Therefore, as shipping costs increase, economics dictate that AlF_3 plants should be located close to their raw material sources, rather than close to the customer as it is cheaper to ship one tonne of AlF_3 than 4.3t of raw materials.

Based on this simple calculation one has to question the long term viability and profitability of new AlF_3 plants being planned, near AlF_3 consuming areas, but far from raw material sources. The recently announced 60kt/y Gulf Fluor plant in the Emirates has consequently suspect economics.

In 2007 at the Frankfurt Fluorspar meeting, this author stated that in China there were 33 AlF_3 plants operating or under construction with a total capacity of 900kt. The capacity numbers shown in **Table 3** for 2010 bear out some of these predictions. As we might expect, the AlF_3 industry in China is also suffering. While some producers are operating at economic plant utilisation rates others are closed temporarily and/or permanently.

Table 4 gives World and Chinese AlF_3 production and consumption assuming no changes in stock levels.

In 2009 China is expected to consume an estimated 350kt of AlF_3 of which 30kt will be from wet process type (low density) production and 320kt will be from dry process production (high density). China will export 90kt of dry process AlF_3 in 2009. Therefore in 2009 total dry process AlF_3 production will be 440kt and wet process production 30kt.

In 2010 domestic consumption is expected, by the author, to be 370kt with virtually no wet production. The wet process is more costly than the dry so generally today only those wet plants owned by smelters are still operating. The Chinese government is expected to mandate, sometime in 2010, the permanent closure of all wet process plants.

Total exports in 2010 are conservatively estimated at 120kt, all from the dry process. Therefore total dry process production in 2010 should reach 490kt of which 370kt as domestic sales and 120kt as exports.

Against a dry process name plate

capacity of 835kt this is a utilisation rate of: 490/835 =58.7%.

However the effective capacity of the dry plants in 2009 is only 530kt. This means the real effective utilisation rate is 490/530 = 92.5%. This is a profitable level of operation unless market forces push the sale prices too low or new capacity comes on stream. Unfortunately, this is soon to happen in China where a further 125kt of dry process capacity is expected to be completed and available for production in 2010.

Market beyond China

The total non-Chinese AlF_3 demand in 2010 should be around 340kt (830kt total world less 490kt Chinese consumption and exports). From this figure we need to remove Russia and India as these are relatively closed markets with nearly all domestic production used locally. Russia produces 70kt and India 20kt making 90kt in total, so the market available to the six main Western producers is therefore 340-90 = 250kt.

The Western producers have a combined AlF_3 capacity of 338kt which means they can operate at 250/338 = 74% of capacity in 2010.

At these rates the Western plants can survive even if their profits will be non existent due to low prices. Of course, if a large new producer such as Gulf Fluor starts production in the next two years one or more of the big six Western producers will be forced to close to make room for them as the Chinese producers are lower down on the cost curve and can better resist new competition.

Today, China has 1.072Mt of installed AlF_3 production capacity of which 242kt is by the wet process (low density) and 830kt is by the dry process (high density). All wet capacity is expected to disappear in 2010. Of the dry plants about 300kt is not currently useable for all practical purposes either due to exaggerated name plate capacity or unusable for technical/economic reasons. The effective dry capacity is consequently 530kt. However, a further 125kt of dry capacity is currently under construction and will be available in 2010. Therefore real Chinese total AlF_3 capacity in 2010 is expected to be about 655kt and real effective utilisation in 2010 should be 490/655 = 75%. This rather low utilisation rate will keep Chinese domestic and export prices low and spur exports in excess of the conservative forecast of 120kt.

This modest utilisation rate obviously makes little economic sense considering that Western producers, who have a higher operating cost, are operating at a similar utilisation rate. The historical reasons for this situation are threefold:

- In 2008 China still had a 15% export tax being applied to AlF_3 which enabled its competitors to secure a large customer portfolio which they maintained into 2009. The Chinese export tax at end 2009 has been reduced to zero.
- Many of the new Chinese dry process plants only began large scale production in 2008 and thus had no large production or sales history on which to construct their 2009 sales position. The situation is different today.

Year	2007	2008	2009E	2010F	2011F
World Al metal production	38 300	37 700	33 400	36 700	39 500
Chinese Al metal production	12 700	13 800	13 500	14 800	17 200
World AlF_3 production	860	845	760	830	900
Chinese AlF_3 consumption	320	345	350	370	430
Chinese AlF_3 exports	95	120	90	120	140
Total Chinese AlF_3 production	415	465	440	490	570
China AlF_3 production as % of world production	48.3	55.0	57.9	59.0	63.3

Table 4 World and Chinese AlF_3 production and consumption by year (kt) *E = Estimate F = Forecast*

Q1 Lowest Cost	Q2 moderate Cost
Do- Fluoride Chemicals Co Ltd Hunan Xianglv Co Ltd.	Most other Chinese plants such as Wei Lai Future Aluminum, Ningxia, Baiyin, Shaowu Huaxin, etc, Mexichem Fluor, IQM, Alufluor
Q3 High cost	**Q4 Highest cost**
ICF (Industrie Chimiques du Fluor) Fluorsid Noralf	Rio Tinto Alcan DDF (Derivados del Fluor)

Table 5 Cost ranking of AlF_3 producers

The big question is what will happen in 2010 and 2011? There is no shortage of installed capacity for AlF_3 production in China. There are of course local shortages of raw materials such as good alumina hydrate and fluorspar and, not to be underestimated, financing. But the Chinese market economy seems to be able to resolve such problems. With this overhang of plant capacity, prices for AlF_3 will and can increase only as a result of an underlying increase in production cost.

The forecasts shown in **Table 4** for 2010 and 2011 are a conservative estimate of Chinese exports. If there is a more aggressive posture the results are decidedly different. Reynolds believe that the Chinese AlF_3 industry, as a reasonable long term objective, will aim to produce 50% more than domestic consumption, with this excess destined for export. This means two-thirds of sales to domestic market and one third for export. In fact for the last 20 years the major European producers have exported at least one-third of production from the regional markets.

Using this reasoning for 2010 the figures would result as follows:

Chinese domestic market	370kt
Exports(50% of above)	185kt
Total China AlF_3 production	**555kt**

Remaining market 830 - 555 = 275 less 90 (Russia plus India) = 185kt as the available market for the six Western producers. This equates to a plant utilisation of only 185/338 = 54.7% . In order to return to a minimum economic utilisation rate of 75% an equivalent capacity of nearly 70kt would have to be closed permanently.

It is obvious that world market prices will soon become completely conditioned and led by the Chinese AlF_3 production cost structure. Those who can profitably keep up, both inside and outside of China, will flourish at the expense of those who, for whatever reason, have higher costs and will consequently fall out of this race to survive.

Table 5 ranks the main AlF_3 producers according to their quartile cost of production, considering only the dry process (except for Alufluor).

Although production cost is probably the most important factor, one needs to remember that the success of a producer in the market place does not depend solely on cost but on all five of the factors (A to E) listed earlier.

In China, as in the rest of the world, there is a ranking among producers and a forecast of who will flourish and who will not. In Reynold's opinion, Chinese exports will be dominated by just two producers, at least for the next few years, Do-Fluoride Chemicals (DFD) and Hunan Xianglv.

The largest exporter in 2008 was Do-Fluoride Chemicals Co Ltd (DFD). This company enjoys top marks in all five of the attributes listed for AlF_3 producers. The second largest Chinese exporter in 2008 was Hunan Xianglv Co Ltd. Hunan has a weak financial structure having gone bankrupt twice in its history. Its quality may also not be as consistent as DFD's. But Hunan Xianglv has a large production, a portfolio of export customers and a low production cost. Between the two of them they could cover virtually all of China's exports. Reynolds expects their respective export quantities and share of the market to grow compared to the other Chinese producers.

In summary the world's AlF_3 market today is not yet in equilibrium but the expected changes in 2010 and 2011 will bring it into equilibrium. ■