

# RECENT EXPERIENCE WITH THE ALCAN COMPACT DEGASSER IN TWO PLANTS

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## Introduction

The First Alcan Compact Trough Degasser (ACD) has now been in commercial service for nearly six (6) years, where it was installed at the Grande-Baie plant in Quebec, Canada. The first application in a plant other than Alcan was at an Alcoa plant in S. Carolina, U.S.A. (Alumax at the time). Altogether, there are now more than fifty (50) units in operation around the world on five (5) continents, of which about half are in Alcan plants and half in plants not owned by Alcan.

The purpose of this paper is to primarily describe two specific plant applications outside Alcan. One application is for ingot production and the other is for continuous casting and rolling of mechanical alloy rod. The paper describes the metallurgical results and quality achieved with the ACD. Hydrogen reduction is compared with model predictions together with analyses of reductions in alkalis and inclusions.

Previous papers have described the metallurgical and operating principles, together with some detailed analysis about the thermodynamic limitations on hydrogen removals as well as percentage reductions of alkalis and inclusions. The applications were based on sheet ingot production.

## Equipment Description

The mechanical components of the Alcan Compact Degasser, shown on Figure 1, are:

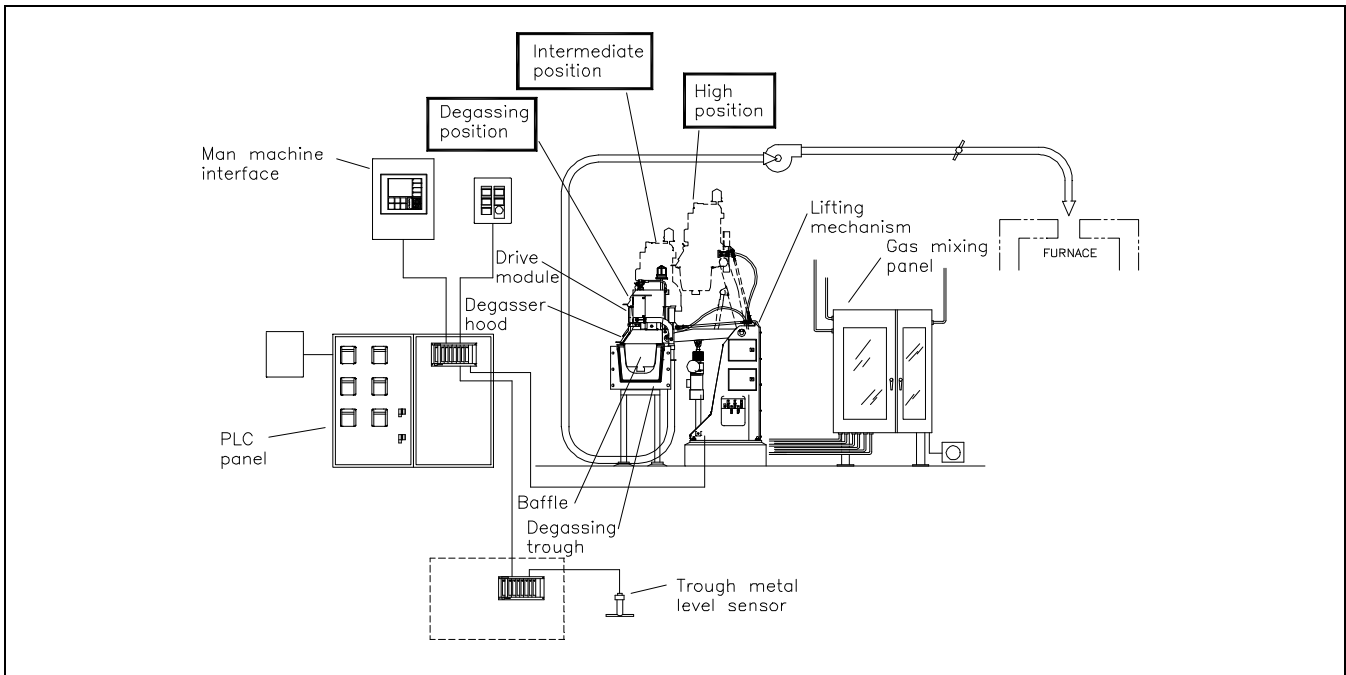
- the degassing trough
- the degasser hood, including the baffle plates
- the drive modules, including the rotors

- the lifting mechanism
- a gas mixing panel
- a fume exhaust system
- a programmable logic control panel
- a man-machine interface
- a trough metal level sensor.

The main function of the degasser hood is to isolate the metal surface from the ambient environment. For this reason, it is designed to be tightly sealed as is required for certain alloys. In addition, it supports the drive modules and the baffle plates, and it contains the fumes and dust generated by the degassing process.

The Alcan Compact Degasser is fitted with several modules designed to run the rotors at the design speed. Each module consists of a frame on which an electric motor and a simple belt drive mechanism are mounted. The assembly is light and has small overall dimensions. A defective module can be easily and rapidly replaced between casts for off-site maintenance without disturbing production.

The degassing rotors are designed to optimise degassing and to minimise metal turbulence at the surface of the melt. Installation and removal are done easily and quickly using common tools. They are generally made of graphite, but ceramic materials are also used successfully. The baffle plates are placed in the trough section to control the metal flow without generating a metallostatic head. The opening below the baffles allows the metal to flow at the rate required to ensure optimum efficiency of the process.



**Figure 1**  
Mechanical components of the Alcan compact degasser

The retraction system is generally an electromechanical assembly which consists of a metal frame and a screw actuator system provided with electric driving systems.

Thanks to a pantograph mechanism, only one actuator is required to move the degassing hood to its TREATMENT, MAINTENANCE or WAITING positions. Another small actuator is also used to actuate the safety locking mechanism of the retraction system. Given the simplicity of the assembly, maintenance is minimum and reliability is excellent. Alternate designs are adaptable to accommodate specific layout requirements. In some installations (see Photo 1), a simple chain support system raises/lowers the hood – or even suspended – from the roof of a furnace.

The gas mixing panel of the Alcan Compact Degasser was designed to provide a precise gas mixing ratio while being fully automated. For that purpose, mass flow controllers are used to accurately supply argon and chlorine flows according to the metallurgical requirements. Safety was also considered in the design of the gas mixing panel. First, a chlorine detector, fitted in the panel, activates if there are leaks. Second, the control logic and piping allow for a complete argon purge of the chlorine circuit at the end of each cast for safer operation and maintenance. Finally, at cast start up, a low gas flow rate is supplied while the rotors are being introduced into the metal to avoid splashing.

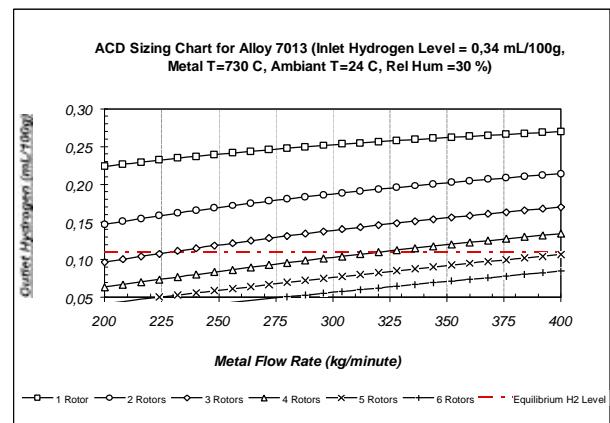
The electrical control systems are greatly simplified by the absence of heating devices. The operational sequence is entirely controlled by a programmable logic controller system. Control of the metal level at nominal height is essential. Generally, this could be accomplished by a metal level sensor such as the one used for furnace tilt control. An industrial man-machine interface

is used to adjust gas flow rates and to warn of any abnormal conditions.

Anticipated Metallurgical Performance

a) *Hydrogen:*

Model predictions for hydrogen removal are made for each application using the Alcan model for ACD performance (see reference in Light Metals 1996, by Peter WAITE of Alcan<sup>1</sup>), a typical example of which is shown in Figure 2.



**Figure 2**  
Prediction for alloy AA 7013

It is to be noted that the metal casting temperature, ambient temperature, alloy type, metal flow and inlet hydrogen level are all critical parameters affecting the final hydrogen level in the cast alloy. The hatched horizontal line in the sketch (Figure 2)

represents the selected humidity level. The actual results are discussed below.

Based on analysis of the predictions for hydrogen, either a 2-rotor, a 4-rotor or a 6-rotor degasser can be chosen to suit the particular application.

*b) Alkaline:*

Predictions using plant operating experience have been made for alkaline removal when operating the ACD. They show anticipated removals for sodium and calcium at both a half and full stoichiometric chlorine inputs.

These predictions are based on relatively low alkaline inputs (less than 20 ppm). At stoichiometric chlorine an average removal from 65% to 75% of sodium can be expected. Calcium, on the other hand, is more difficult to remove, and a range of 40% to 60% can be expected.

Case 1 – Reycan, Cap-de -La Madeleine, Quebec, Canada

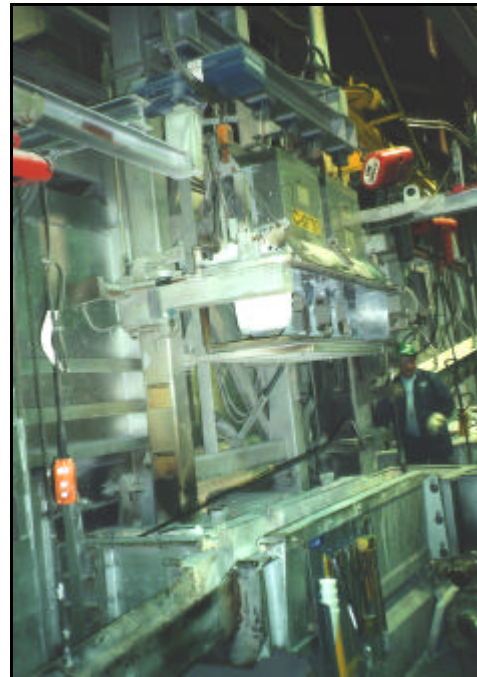
Application

In 1998, approval was given by the board of Reycan to modernise DC613 to include the pit and the casting troughs and to install a degasser for the production of ingots. The Alcan Compact Trough Degasser was chosen for this application, which, as can be seen on Photo 1, is contained in a very restricted area. Due to its simplicity in design and small floor space requirement, the ACD can be installed in casthouses where conventional degassers can not or are impossible to be installed.

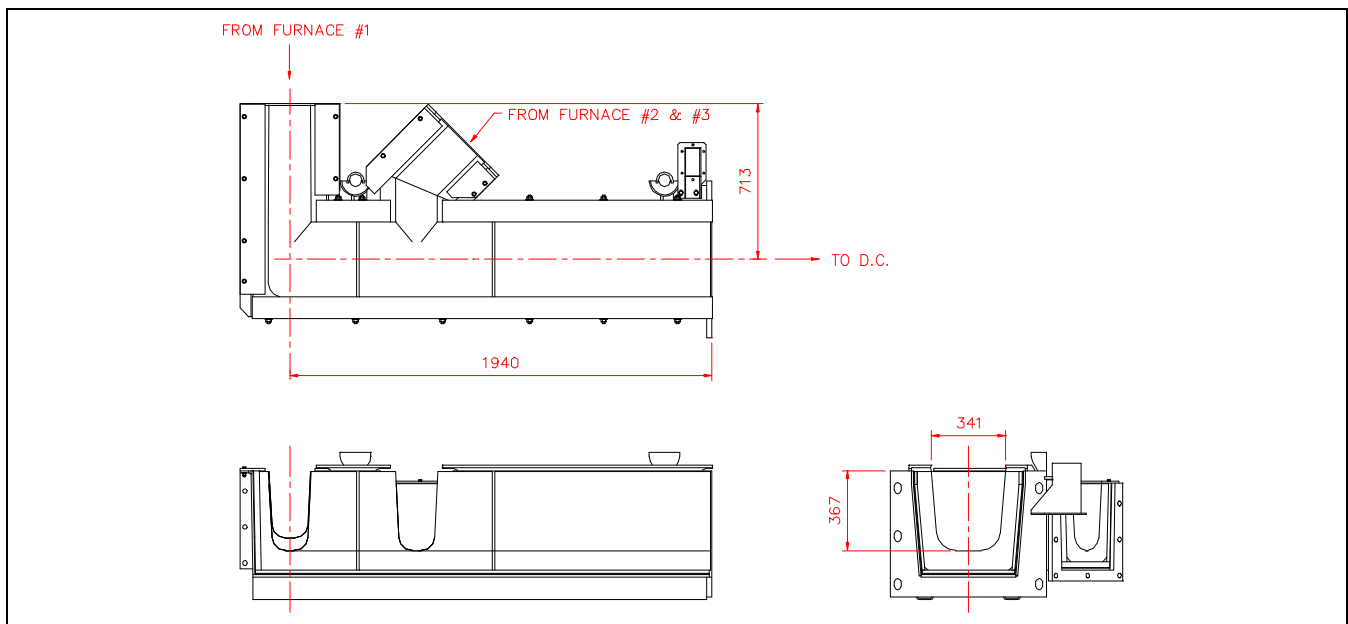
Three furnaces, with a plan to install a fourth, feed the casting pit. The modernisation was to ensure compliance for meeting strict quality standards for a wide variety of alloys. In particular, there would be a need for hydrogen removal and inclusion removal for the 2XXX, 4XXX and 7XXX alloys. Where there are frequent alloy changes, the ACD is ideal due to zero metal hold-up when

changing the alloy. As a consequence, it is not necessary to provide heating to keep the metal at the required temperature.

The chosen model at Cap-de la-Madeleine is a 2-module system, with 4 rotors, degassing up to 400 kg /min. As can be seen in the sketch (Figure 3), the trough design is adapted to the casting pit needs, for which three (3) furnaces supply metal through the degasser. A transition section of trough at the inlet and a CFF at the outlet permit the section under the ACD to be degassed.



**Photo 1**  
ACD – Reycan, Cap-de-la-Madeleine



**Figure 3**  
Sketch of trough, Reycan, Cap-de-la-Madeleine

The metal level in the trough needs to be maintained at an optimum of 200 mm. The system is designed however to accept a metal level of 175 mm (6.9"), at which time an alarm will sound to alert the operators that the level is getting too low ; at 150 mm (5.9"), the degassing is not considered sufficient and the ACD is stopped. At Reyacan, a Selcom (laser) has been placed above the CFF filter, at approximately 0.30 meters from the exit of the degasser, to monitor the metal flow and level in the degasser, which is controlled manually.

#### ACD Operating Conditions

The rotor speeds for each of the four (4) rotors are fixed at 800 rpm with a mixture of argon and chlorine fed to the first three (3) rotors but only argon gas to the fourth (last) rotor; baffles are located at the entrance to the degasser and at the exit of the degasser (2 baffles in total). Gas flow can be varied to suit the specific needs for quality and is a function of the metallurgical requirements.

#### Testing Conditions and Methods

##### a) Specific Parameters:

Typically for this application, total argon flow rates are 45 litres/min/rotor and total chlorine at 500 ml/min. Furnace # 3, located at the longest distance from the degasser (approx. 25 metres of trough length) provided the metal.

##### b) Hydrogen Measurements:

Alscan readings were taken on several occasions following the installation of the degasser to check on the metallurgical performance. These readings were taken downstream of the degasser – just at the DC station – whose results are shown in Table 1. Supplementary readings were taken in the Fall of 1999, nine (9) months since commissioning, at intervals during the drop at the exit from the furnace, at 3 metres before the degasser, and at the exit of the degasser. These results are also shown in Table 1. All readings are for alloy type AA7013, essentially a high zinc alloy. Measurements are taken several minutes after the start to allow for sufficient time to preheat the hydrogen probes and perform a short cycle to ensure equilibrium and steady state conditions for casting parameters and instrument readings.

##### c) Inclusion Samples:

Similar to the hydrogen measurements but with a short delay because of preheating of the sample ladle and handling of the filled PoDFA crucible, the estimated times for the samples "pre" ACD are around t=11 and t=31 min (see actual) and for "post" ACD t=13 and 33 min. Averages of the 2 readings are reported in Table 2. Samples were also taken after commissioning, in the Fall of '99, before/after the degasser.

Samples have been analysed by Bomem, the manufacturer of Alscan and Podfa analysers. A furnace treatment using salt fluxes is used prior to the drop.

#### Discussion and Conclusion of Results for Reyacan

Before taking delivery of the degasser, an evaluation was made of the hydrogen levels prior to the degasser. STAS uses a model to predict hydrogen levels and to size the degasser to suit a particular client's needs. Consideration is given to flow rate, alloy type, metal temperature in the degasser, etc.

**Table 1**  
*H<sub>2</sub> removal (Alloy 7013)*  
*Alscan readings*

Metal Flow (kg/min)	Relative Humidity (%)	Ambient Temp. (°C)	Outlet Furnace		3 Metres before ACD		"Post" ACD	
			H <sub>2</sub> (ml/100 g)	Metal Temp (°C)	H <sub>2</sub> (ml/100 g)	Metal Temp (°C)	H <sub>2</sub> (ml/100 g)	Metal Temp (°C)
250	23	24	0.34	764			0.11	696
250	23	24	0.61	767			0.10	706
250	23	24	0.44	766			0.11	720
325	28	19	0.39	760			0.10	699
325	28	19	0.45	746			*	705
325	28	19	0.42	742			0.12	700
<b>325</b>	<b>30</b>	<b>18</b>			0.36	<b>730</b>	0.11	} Average 700 °C
<b>325</b>	<b>30</b>	<b>18</b>			0.32	<b>729</b>	0.11	
<b>325</b>	<b>30</b>	<b>18</b>			0.34	<b>728</b>	0.10	
<b>325</b>	<b>30</b>	<b>18</b>			0.35	<b>731</b>	0.10	
<b>325</b>	<b>30</b>	<b>18</b>			0.36	<b>732</b>	0.10	

\* Problem with probe

Three furnaces, with a planned fourth, were to feed metal to be degassed. One of the furnaces is less than 1 metre from the degasser, with the others up to 25 metres away. Estimating input hydrogen levels to the degasser, therefore, was very difficult.

It is known that for very long trough lengths, there would be a considerable temperature drop along the trough with corresponding reductions in hydrogen content. Expected performance was requested based on entry levels of 0.22 ml/100 gm.

Measurements taken at furnace # 3, with the longest trough length of 25 metres (75 feet), showed entry levels to be much higher (see Table 1) at an average of 0.44 ml/100 gm, varying from 0.34 to as high as 0.61 ml/100 gm.

Subsequent measurements nearer to the degasser (difficult access to get closer) at about 3 metres (10 feet) showed, as expected, considerably lower hydrogen levels at an average of 0.34 ml/100 gm as compared to the furnace outlet. Dissolved hydrogen is clearly diffusing out of the molten metal as the temperature drops along the trough (see corresponding temperatures in Table 1).

The humidity levels at the time the readings were taken were low (November 1999). For the flow rate of 250 kg/min, in theory, a lower H<sub>2</sub> content could have been achieved (at approximately 0.08 ml/100 gm) for a 4-rotor system; the results gave 0.11 ml/100 gm as per the predictions based on the ambient humidity. The results showed reductions of hydrogen as the model predicted (Figure 2), to an average of 0.11 ml/100 gm. Although more than one flow rate was measured, the output levels remained remarkably constant.

Turning to the inclusion removal performance, a titanium boride grain refiner is added just after the degasser. The inclusion count was predominantly of this inclusion type (more than 90% on average). The remaining inclusions (see Table 2) are of the "hard" inclusion type, consisting of carbides and spinels; more inclusions in the incoming metal leads to a higher removal. On

the other hand, the cleaner the incoming metal, the lower the removal.

**Table 2**  
*Inclusion samples (Data to be supplied)*

AA Code	PoDFA "pre" (mm <sup>2</sup> /kg)	PoDFA "post" (Hard Particles) (mm <sup>2</sup> /kg)
7013	0.840	0.029
7013	0.901	0.005
7013	0.022	0.015
7013	0.024	0.013
7013	Unavailable	0.004
7013		0.008
7013		0.007
7013		0.005
7013		0.008
7013		0.008
7013		0.007

Case 2 – Southwire, Kentucky, U.S.A.

Application

In 1998, a team from Southwire visited the Grande-Baie plant to discuss a possible application for the sole purpose of removing alkalines using the ACD in a continuous casting application. The Southwire board of directors approved the new project for a market need for low volume products. Regular alloy changes made the ACD an attractive option.

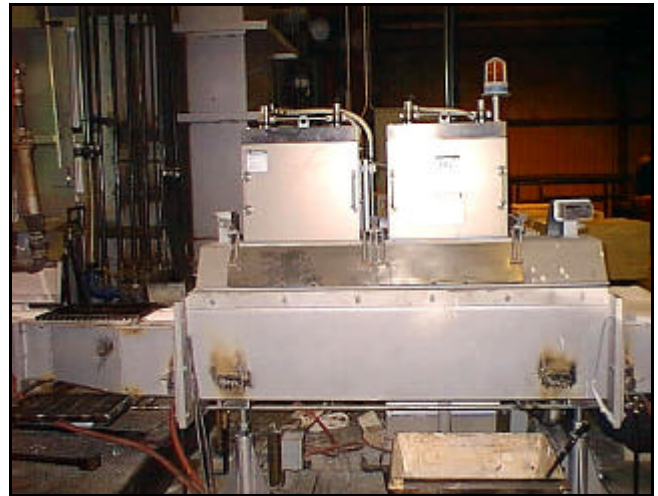
The first consideration was for sodium removal with levels as high as 10 ppm anticipated. A second consideration was to be able to meet lower hydrogen levels in the future as customers become more and more demanding. This study has only concentrated on sodium removal.

The anticipated application was for an optimum flow rate of 100 lbs/min (45 kg/min). Normally, a 2-rotor system would be

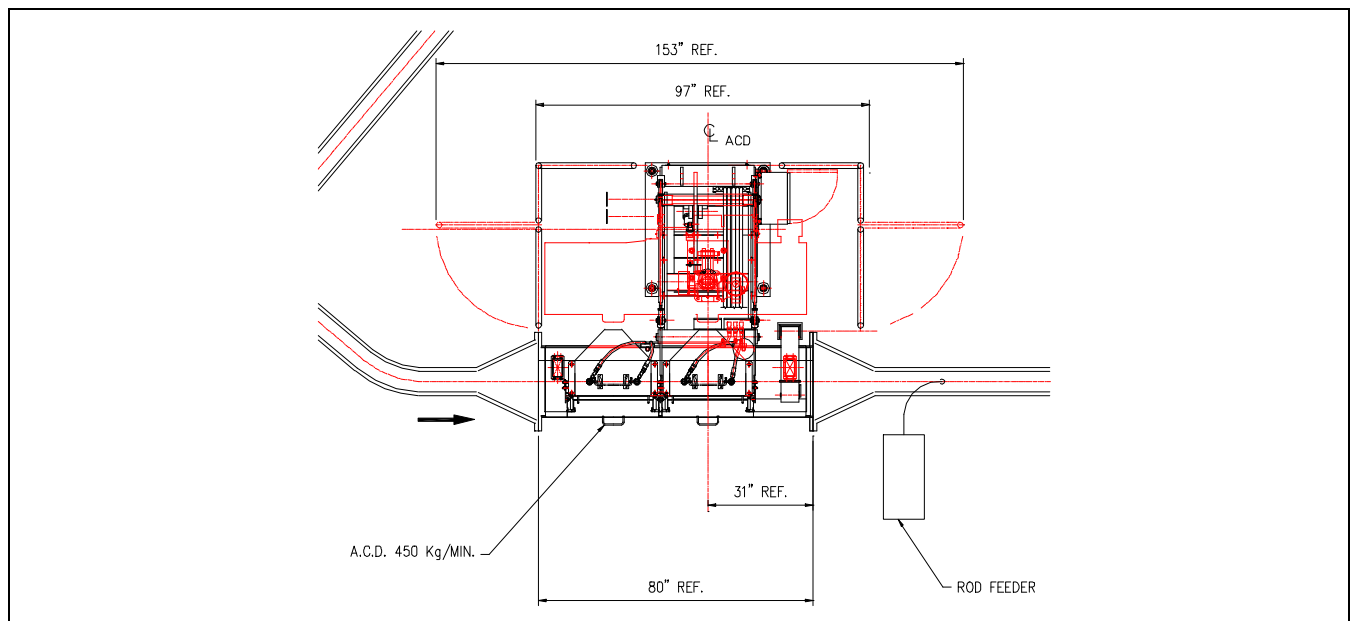
suitable for this specific need. However, it was decided to take a different approach to satisfy Southwire in an application where there had previously been no data. The following step-by-step approach was adopted:

- 1) Purchase of a 4-rotor system for the 45 kg/min (100 lbs/min) new casting line.
- 2) Carry out lengthy trials using 2 and 4 rotors from the same machine.
- 3) Following successful trials using only 2-rotors (assuming success), transfer the 4-rotor system to another existing casting line (300 lbs/min) and install a 2-rotor system in place of the previous 4-rotor system.

A sketch and photograph of the installation are shown on Photo 2 and Figure 4.



**Photo 2**  
*Southwire, Kentucky*



**Figure 4**  
*Installation at Southwire*

ACD Operating Conditions

See Reycan application. Similar operating conditions.

On one occasion, the degasser was run with only two (2) rotors. Argon and chlorine gases were distributed in equal volumes to both rotors.

**Table 3**  
*OES samples (Flow rates: 40-45 kg/min))*

Ar (lit/min)	Alloy	# Rotors	Total Cl <sub>2</sub> (ml/min)	"Pre" ACD		"Post" ACD	
				Na (ppm)	Temp (°C)	Na (ppm)	Temp (°C)
181	5052	4 rotors	599	2	736	0	727
181	5052	4 rotors	599	2	804	1	788
181	5052	4 rotors	600	0	743	0	729
181	5356	4 rotors	599	3	747	1	727
181	5356	4 rotors	599	15	743	3	718
181	5356	4 rotors	599	3	743	2	732
181	1350	4 rotors	598	3	746	1	736
100	1350	2 rotors	397	1	739	1	732
<b>Average Removal Efficiency:</b>						<b>66%</b>	

Alkaline Samples

Samples were taken during the continuous casting operation, sometimes at intervals of several hours. Samples were then taken to the laboratory for analysis using optical emission spectroscopy (OES). Only sodium levels have been investigated to date. On the other hand, a CFF filter is placed downstream at 229 cm (7'6") from the degasser.

Discussion and Conclusion for Southwire

In Table 3 are the results from several tests taken during the Fall of '99. Readings were reported as percentages and are rounded to the nearest ppm.

There is a long trough section between the furnace and the degasser at 544 cm (17'10"), with relative flow rates varying from 36 kg/min (4800 lbs/h) to 45 kg/min (6000 lbs/h).

The location of the sampling was 29 centimetres (11.5") on either side of the degasser. Incoming sodium levels on average are much lower than were previously anticipated (order of 10 ppm). Only a few readings were as high as this level.

Chlorine inputs were typically above stoichiometric for the 4 rotors (setting at 600 ml/min). A stoichiometric level is 280 ml/min. As per the original programme, 2 rotors were also tested, with a corresponding lower chlorine input – but still higher than stoichiometric.

The results show an average reduction efficiency of 67% for exceptionally low sodium input levels. This reduction percentage is calculated using ppm, which have been rounded to the nearest whole number.

Reference:

P.D. Waite, "Improved Metallurgical Understanding of the Alcan Compact Degasser after Two Years of Industrial Implementation in Aluminum Casting Plants", Conference Proceedings at the 127<sup>th</sup> TMS/AIME Annual Meeting, San Antonio, Texas, Feb 1998, pages 791 to 796.