RECENT EXPERIENCE WITH THE ALCAN COMPACT DEGASSER IN BILLET AND CONTINUOUS CASTING

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ABSTRACT – The Alcan Compact Trough Degasser (ACD) has been operating in many plants continuously for more than five years in North America, Europe, Australia, South Africa and Asia, not only within Alcan installations but also in non-Alcan plants. The early experience was with can stock production (ingots), but more recent experience has been with billets, remelt ingots and continuous casting. This paper updates performance results, not only for degassing but paying particular attention to alkaline removal and inclusion removal. Extensive testing by various companies, sampled from the more than 40 plants now using the ACD, has shown that up to 90% alkaline removal is possible and up to 85% inclusion removal has also been achieved. Conditions are described under which these removal rates are obtained using both LimCa and PodFa results for inclusion removal and Alscan for hydrogen removal. These conditions include the relative humidity in the cast house, the type of alloys degassed, the temperature of the molten alloys and the quantities of chlorine and argon gas.

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.

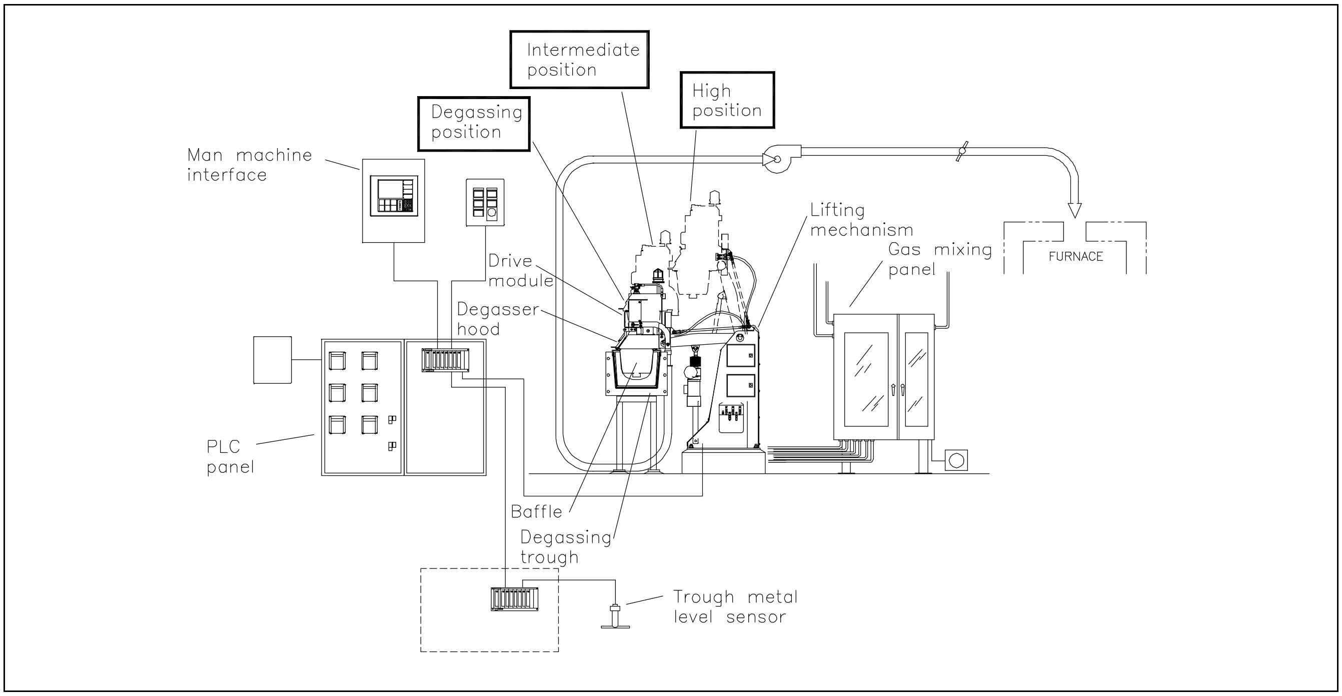

Figure 1
Mechanical components of the Alcan compact degasser

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.

The retraction system is generally an electro-mechanical 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, 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 can 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

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 [1]), a typical example of which is shown in Figure 2.

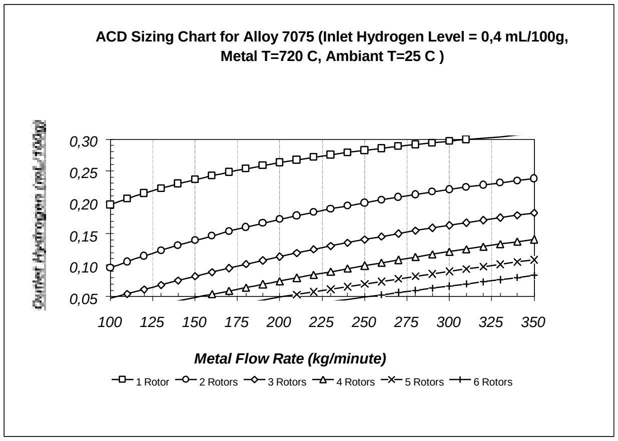

Figure 2
Prediction for alloy AA 7075

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.

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.

Alkalines. Predictions using plant operating experience have been made for alkaline removal when operating the ACD. Anticipated removal for sodium and calcium can range up to stoichiometric chlorine inputs.

These predictions are based on relatively low alkaline inputs (less than 20 ppm). At stoichiometric chlorine levels, an average removal of between 65% and 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.

Inclusion Removal. Tests have shown improved inclusion removal when using the ACD as compared with conventional degassers.

The removal efficiency is also a function of the incoming cleanliness level. The higher the level of inclusions (as measured by Podfa), the higher the removal efficiency; conversely, the lower the incoming level, the lower the removal efficiency.

CASE 1 – HOOGOVENS, DUFFEL, BELGIUM

Application

In 1998, approval was given by the board of Hoogovens to modernise DC3 to include a new "hot top" technology and metal treatment facilities including a degasser for the production of billets. The Alcan Compact Trough Degasser was chosen for this application (Photo 1). 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.

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, alkaline removal and inclusion removal for mainly the 2XXX, 6XXX 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.

Photo 1
ACD – Hoogovens, Duffel, Belgium

The chosen model at Duffel is a 3-module system, with 6 rotors, degassing up to 450 kg /min (Figure 3). As can be seen in Photo 1, the trough design is adapted to the metal flow through the degasser. Transition sections of trough at the inlet and outlet permit the section under the ACD to be degassed.

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 Duffel, a Selcom (laser) has been placed at approximately 3.5 meters to control the metal flow and level in the degasser.

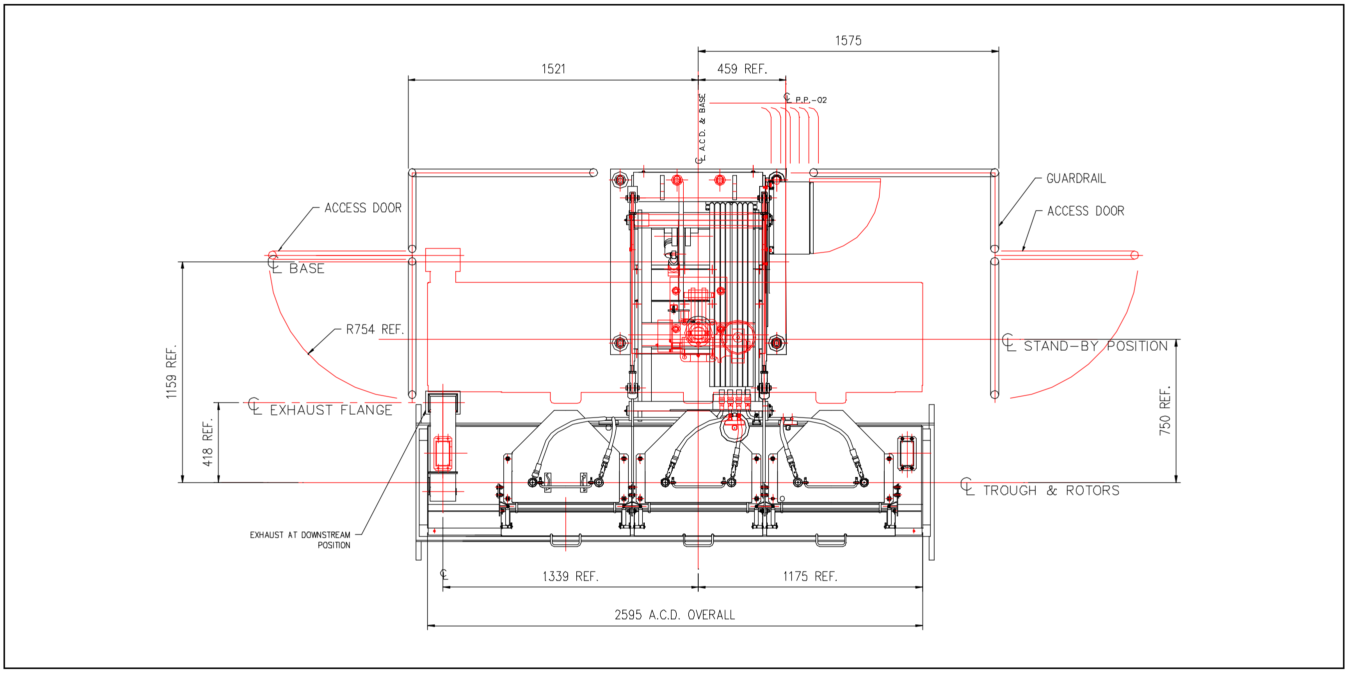

Figure 3
Sketch of trough, Hoogovens, Duffel

ACD Operating Conditions

The rotor speeds for each of the six (6) rotors are fixed at 800 rpm with a mixture of argon and chlorine fed to the first five (5) rotors but only argon gas to the sixth (last) rotor; baffles are located at the entrance to the degasser, between rotors 3 and 4, and at the exit of the degasser (4 baffles in total). Gas flow can be varied to suit the specific needs for quality and is a function of the metallurgical requirements. Later tests used only four (4) rotors with a mixture of argon and chlorine fed to the first three; argon only to the fourth.

Testing Conditions and Methods

Specific Parameters. Typically for this application, total argon flow rates are 45 litres/min/rotor, and total chlorine varied from 350 to 1000 ml/min. The furnace is located at 4.5 meters from the degasser.

Hydrogen Measurements. Simultaneous "pre" and "post" ACD start of the first measurement at t=10 min and second measurement at t=30 min. This method of testing (start at t=10 min) allows for sufficient time to preheat the hydrogen probes and perform a short cycle to discard any moisture present in the probe, prior to the actual measurement, and to ensure equilibrium and steady state conditions for casting parameters and instrument readings.

Temperature and relative humidity of the ambient air in the casthouse at the time of the measurements are monitored.

Alscan readings were taken on several occasions following the installation of the degasser, with all six (6) rotors operating, to check on the metallurgical performance. These readings were taken approximately one half a metre (18") before the degasser and, for "post" ACD, at the same distance downstream, whose results are shown in Table 1.

Table 1
H_2 removal – Alscan readings

AA Code	Metal Flow (kg/min)	Number of Rotors	Temp. (°C)	H_2 "pre" ACD (average 2 readings)		H_2 "post" ACD (average 2 readings)	
				(Ml/100 g)	Metal Temp. (°C)	(Ml/100 g)	Metal Temp. (°C)
6082	139	6	16,4	0,41	768	0,16	738
6082	139	6	16,5	0,27	756	0,14	731
5083	154	6	17,3	0,31	741	0,14	720
7175	124	6	16,8	0,27	722	0,14	685
7175	114	6	14,5	0,29	721	0,13	691
2030	130	6	15,8	0,32	742	0,14	714
2030	154	6	28,2	0,27	740	0,15	712
6262	255	6	31,6	0,41	748	0,21	729
7075	115	4	18,5	0,33	733	0,19	718
7075	115	4	17,4	0,36	725	0,16	706
2030	106	4	16,8	0,32	734	0,16	717
2030	106	4	16,8	0,27	744	0,13	727
2030	106	4	18,1	0,29	748	0,12	

Supplementary readings were taken in the Fall of 1999, eleven (11) months since commissioning, with four (4) rotors operating. At the required flow rates, the number of rotors is more than sufficient to reduce the hydrogen to equilibrium levels for the ambient conditions. These results are also shown in Table 1. Readings are for several alloy types, including AA6262, 2030 and 7075.

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. 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.

On the other hand, a CFF filter is placed downstream of a dam at 70 cm (28") from the degasser.

Alkaline Samples. Samples were taken during the operation. Samples were then taken to the laboratory for analysis using optical emission spectroscopy (OES). Sodium and calcium levels have been presented here; there was virtually no reduction of lithium, which was also measured.

DISCUSSION AND CONCLUSION OF RESULTS FOR HOOGOVENS

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.

Due to the relatively long trough length between the furnace and the casting pit, temperatures of the molten metal at the input to the degasser are relatively high.

As operating experience has improved, a reduction to four (4) rotors has been made with no effect on the average reductions in hydrogen levels as is to be expected from the predictions made for the different flow rates, alloys and the ambient humidity levels. The output levels are averaging 0,15 ml/100g.

Based on predictions for alkaline removal (Table 2) and the levels of chlorine used (up to 1.0 l/min), the efficiencies were as expected, with sodium removal varying from about 50% to 90%. Calcium removal was much lower at between 10% and 25%. These figures are entirely in line with, less than or close to stoichiometric additions of chlorine for sodium. If higher calcium removals were required, slightly higher volumes of chlorine gas would be required.

Table 2
Alkaline samples

AA Type Alloys	Nb of Rotors	Cl_2 (ml/min)	Na "pre" (ppm)		Na "post" (ppm)		Ca "pre" (ppm)		Ca "post" (ppm)		Removal Efficiency	
			1	3	2	4	1	3	2	4	Na (%)	Ca (%)
6262	6	483	7,6	7,9	2,1	1,5	36,2	35,5	37,6	34,3	76,8	-0,3
6262	6	1000	5,1	4,5	1,4	1,0	16,1	14,7	11,8	11,4	75,0	24,7
6262	6	1000	5,5	4,6	1,8	1,5	13,5	13,2	11,4	11,3	67,3	15,0
6262	6	1000	4,5	4,6	2,3	1,1	14,1	14,3	12,2	9,8	62,6	22,5
7075	4	670	8,5	8,2	4,3	4,3	28,9	28,3	25,4	26,1	48,5	10,0
7075	4	1000	9,2	8,0	1,0	0,6	46,7	47,0	36,9	37,6	90,7	20,5
2030	4	1000	10,1	9,9	1,5	0,4	33,1	33,9	23,7	27,3	90,5	23,9
2030	4	350	0,1	0,1	0,1	0,1	32,9	32,7	27,7	27,0	0,0	16,6
2030	4	335	0,1	0,1	0,1	0,1	34,3	35,9	29,6	30,2	0,0	14,8

Turning to the inclusion removal performance (see Table 3), the inclusion count was predominantly of the "hard" inclusion type, consisting of carbides. The removal efficiency for 6 rotors was particularly high, explained partly by the relatively low metal metal flow rate for a 6-rotor system.

Table 3
Inclusion removal performance

Alloy Type	"Pre" ACD (Podfa) Total Inclusions (mm^2/kg)		"Post" ACD (Podfa) Total Inclusions (mm^2/kg)	
6262	0.036	0.010	trace	trace
6262	0.032	0.027	trace	0.001
6262	0.119	0.449	0.010	0.004
2011	0.001	0.003	trace	trace
2011	0.003	0.001	trace	trace
6262	0.037	0.057	0.006	trace
6262	0.098	0.116	0.004	0.004

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.

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.

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.

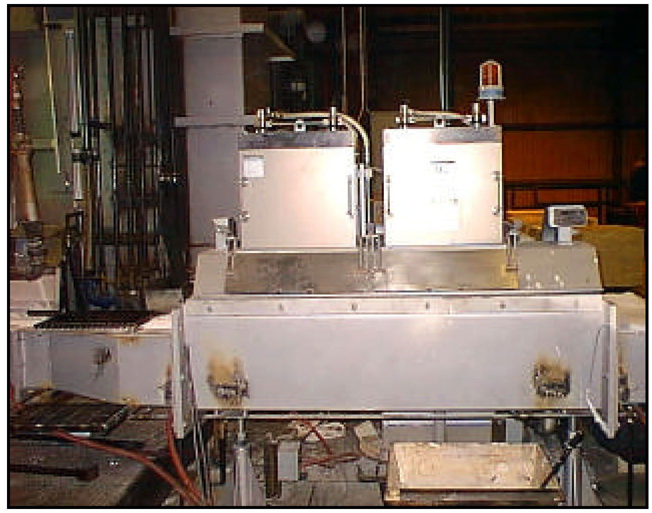

Photo 2
ACD – Southwire

Discussion and Conclusion for Southwire

In Table 4 are the results from several tests taken during the Fall of '99. Readings were reported as percentages and are rounded to the nearest ppm.

Table 4
OES samples (Flow rates: 40-45 kg/min))

Ar (ml/min)	Alloy	# Rotors	Total Cl_2 (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
Average Removal Efficiency:						**66%**	

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.

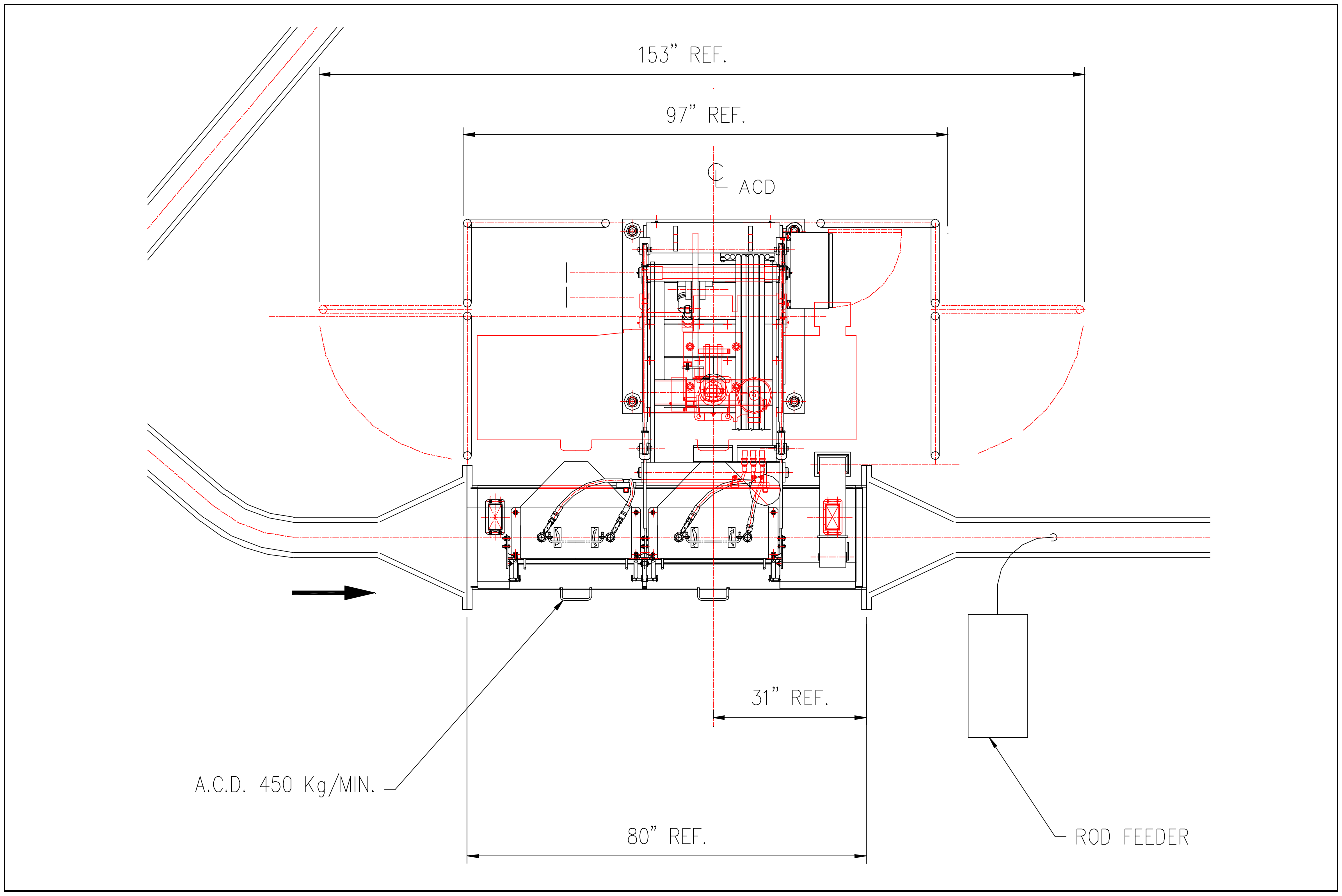

Figure 4
Installation at Southwire

References:

1 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 127th TMS/AIME Annual Meeting, San Antonio, Texas, Feb 1998, pages 791 to 796.