MODERN TRENDS IN POT PREHEATING AND START-UP OF HIGH AMPERAGE CELLS- KEY INSIGHTS FROM INDUSTRY EXPERIENCE

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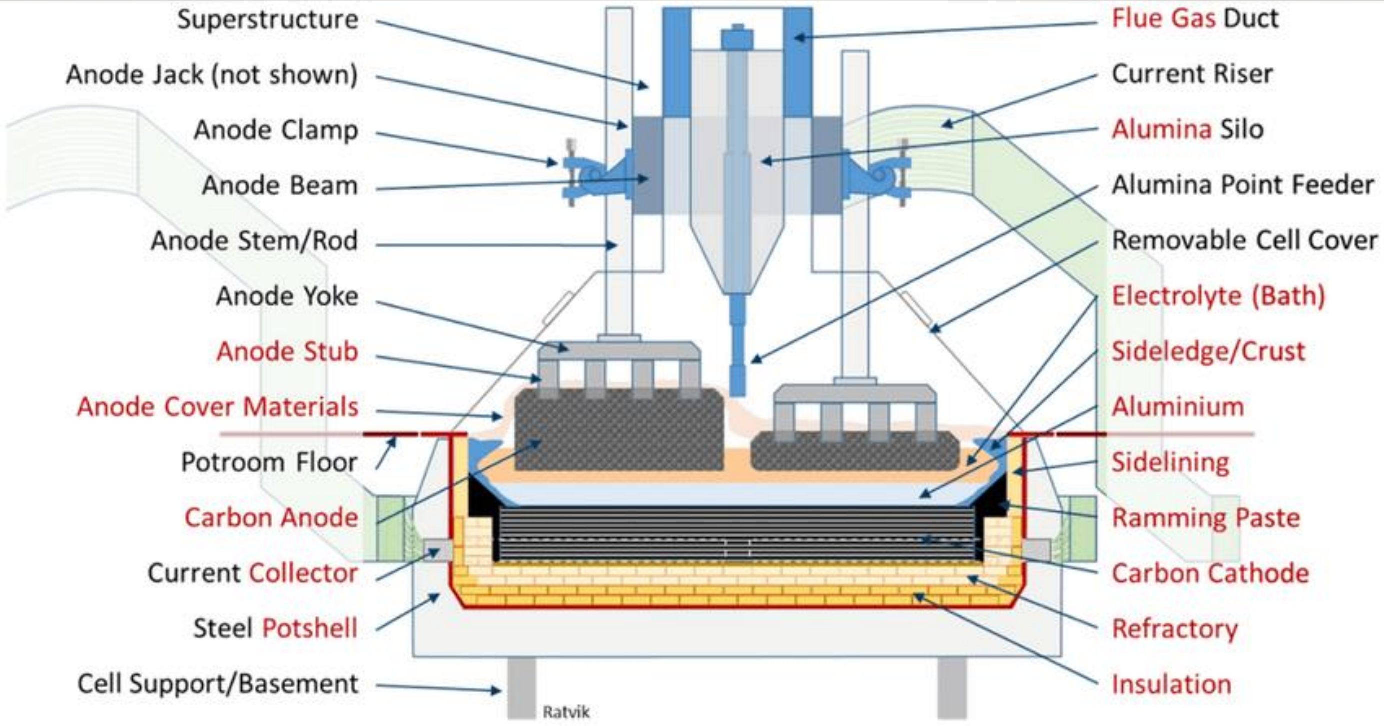
WHY HIGH AMPERAGE POTLINE ?

- High amperage pots are the cornerstone of modern aluminium smelters and are always preferred due to economic and operational advantage
- Higher productivity
- Reduced energy cost per ton
- Lower capital investment per ton of metal
- Faster return on investment
- improved process stability and better performance
- These are a few driving forces behind building a higher amperage potlines
- Modifications in anode design, lining improvements, magnetic compensation, and control strategies in EGA's DX Plus and DX Ultra Plus technologies result in highly stable and promising pot performance and fits the description mentioned above

CROSS SECTION VIEW OF PREBAKED POT



INTRODUCTION

Pot preheat (resistor preheat)

- The objective of preheat
- Pot preparation for preheat
- Raw materials
- Energising/Cut in the pot
- Duration of preheat
- Monitoring Cathode temperature
- Optimum preheat rate
- Risk involved during preheat

Pot start up/Bath up

- Bath–up Preparation
- Bath pouring
- Post Bath up operations
- Super high amperage cells (info)
- Dry Start up (info)

WHY DO WE PREHEAT THE POT

- Uniform heating of the cathode
- Elimination or reduced duration of start up anode effect
- To bring cathode block temperature to ≥900 ºC
- Quick stabilization of pot after bath up at low voltage
- Reduction of the risk of bath and metal infiltration
- Elimination of cathode air burn (Hot spots)
- Protection of the lining

POT PREPARATION FOR PREHEAT

- After thorough pot inspection (Comprehensive check list),Then the preparation work is started.
- Clean the cathode surface with commercial vacuum cleaner
- Using the anode template, spread the graphite or resistor coke on the cathode
- Fix the anodes in the pot using PTM
- Anode covering with thermal insulation
- Fixing the preheat flexibles
- Side/end walls loading with pure crushed bath and soda (Sandwich cover) /specifications of crushed bath
- Installation of start up fuse
- Preheat monitoring (Most critical)

TAPPED BATH AND RESISTOR COKE ANALYSIS

Characrestic	Unit	Limit
Al_2O_3	Wt%	≤8
C	Wt%	≤0.3
Fe_2O_3	Wt%	≤0.1
Sio_2	Wt%	≤0.15
P_2O_5	Wt%	≤0.018
AlF_3	Wt%	≤ 12
CaF_2	Wt%	≤6.0
MgF_2	Wt%	≤0.5
LiF	Wt%	≤1.0
Na_3Alf_6	Wt%	≥75

Characteristic	Unit	Limits
Fixed Carbon	Wt. %	≥ 97-98
Ash Content	Wt.%	≤ 2.0-2.02
Real density	Gms/cm^3	2.10 Min
Electrical Resistivity at Pressure 0.015 Mpa and at room temperature	µΏm	2000

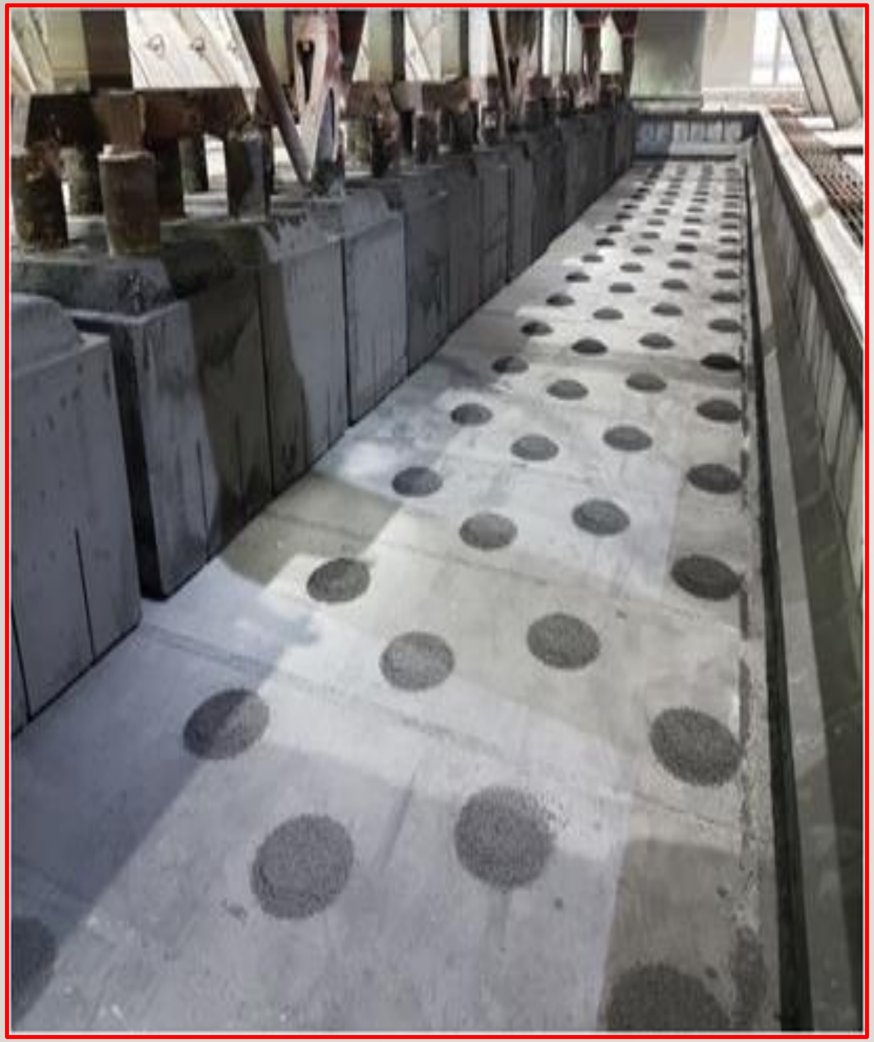
POT PREPARATION

Spreading the resistor coke

Anodes are fixed by crane and gap between anodes are covered with insulation blanket– It’s a different technology pot

Anode stub marked with chalk to facilitate top covering

Anode top is covered with ACM



Graphite bed under anode shadow of high amperage pot

Anodes are well covered with crushed bath to avoid the heat losses

ACHIEVE HIGH AND UNIFORM CATHODE TEMPERATURE
"AIR TIGHT" CAVITY PREPARATION

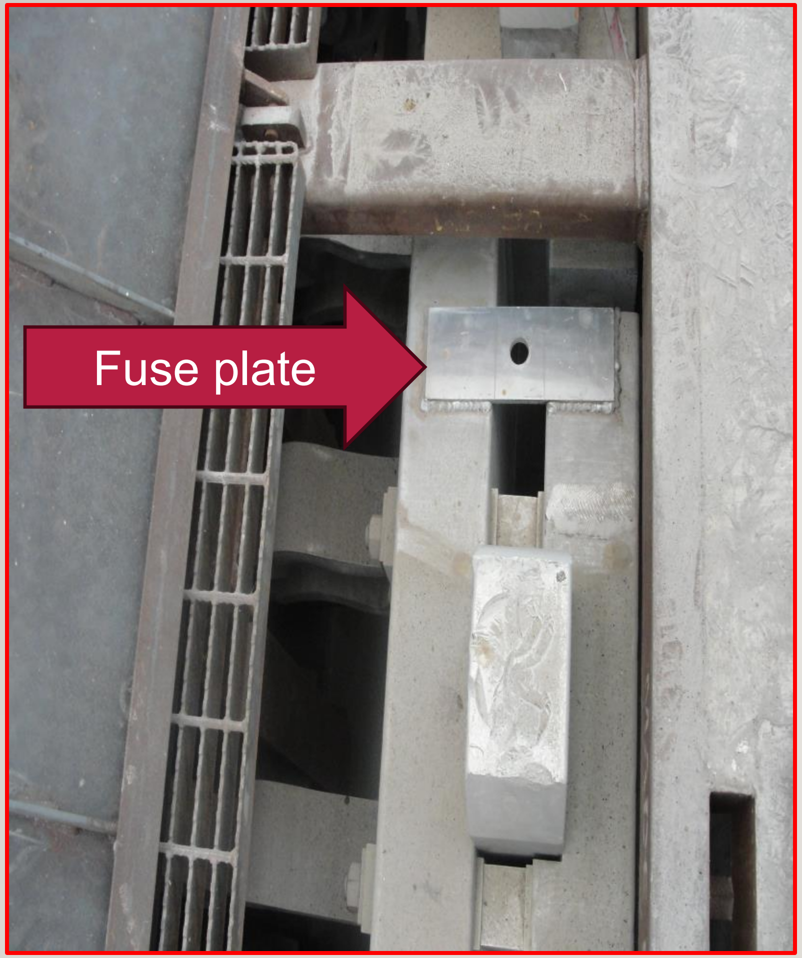
Different technologies use different height of anode top covering before preheat. In this picture anodes are fully covered.

POT PREPARATION CONTINUE….

Flexibles are being installed

Flexibles installed

Side wall loading completed
Crushed bath-soda-crushed bath



Fixing start up fuse

Start-up fuses general view

Hooded Pot, ready for preheat

Short circuit wedge puller in place

HI FORCE WEDGE PULLER

Hi force jack device which was used initially

This device was developed by EGA, it's compact, highly safe and easy to operate

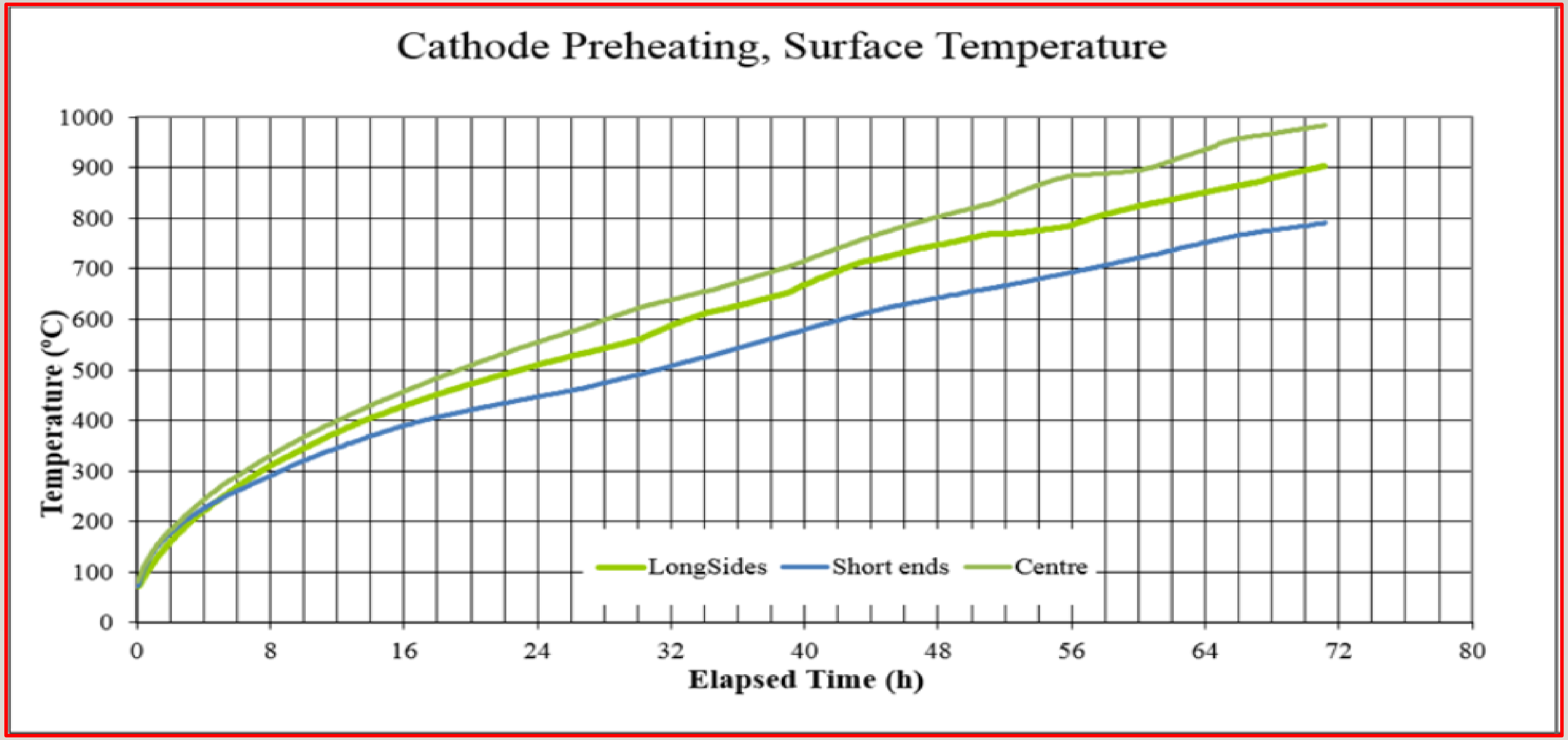
CUT IN/ENERGISING THE POT

- Prior to cut in the pot, ensure, duct damper is on closed position (re verify)
- Using the wedge puller device, all the short circuit wedges are removed one by one but not in proper sequential order
- The pot is cut in at full load and with utmost care.

MONITORING THE PREHEAT

- The objective is to have good current distribution in anodes and acceptable voltage drop between rod and flexibles
- Anode current distribution. These days, some vendors provide the device whereby you can monitor current distribution in real time any time without operator measuring it.
- Contact voltage drop
- Cathode surface temperature (Thermocouples are installed under the breakers)

HIGHER AND UNIFORM TEMPERATURE



Abnormalities during preheat

- Uneven current distribution
- Hot spots below some anodes, temperature might reach 1100ºC causing oxidation of cathode
- Insufficient preheat temperature
- Red stubs or red pins
- Anode burn off- This is a typical case of poor anode sealing/poor quality of anodes
- High or low rate of heating.
- For graphitised preheat average rate of preheat of 15 ºC is considered to be good
- Short side temperature not picking up properly as higher amperage pots are designed to dissipate heat

These challenges require advanced preheating strategies, such as computational fluid dynamics (CFD) for heat distribution, automated control systems, and robust safety protocols.

COMMON PROBLEMS DURING PREHEAT AND BATH UP

Red stub during preheat

Transition joint air cooling

POT START UP-POT BATH UP

➢ POT BATH UP STAGES

- Bath up preparation
- Pot Bath up
- Post bath up operation

➢ BEFORE BATHING UP THE POT

- Tighten the anode clamps
- Anode marking reference with chalk line
- Remove the flexibles
- Remove thermal insulation blanket

ANODE CLAMPING AND FLEXIBLES REMOVAL

POT START UP-POT BATH UP

BATH POURING STEPS

- Predetermined quantity (13-14 ton) of liquid bath is poured in controlled manner
- Ideal temperature of the bath should be above 970-980ºC
- Raise the anode beam while maintaining all anodes immersed in molten bath
- Maintain about 45-48cm bath height depending upon cathode cavity volume available
- Add 15-20 dumps of alumina to liquid bath in pot(this depends upon technology to technology)
- Pot voltage is maintained around 10V
- In some technology, 3-4 anodes (predetermined) are raised about a cm after bath up
- Gas duct damper is opened completely

BATH TAPPING IN PROGRESS

BATH POURING USING START UP TILTER

Start-up Control Sheet

Line #		Pot #		Cut-in Date & Time	Bath-up Date & Time

Date	00/01		01/01			02/01			03/01			04/01			05/01			06/01				07/01	14/01	21/01	28/01	04/02	11/02	20/02
Day	Day 1		Day 2			Day 3			Day 4			Day 5			Day 6			Day 7			Day 8	Days 9-14	Days 15-21	Days 22-28	Days 29-35	Days 36-42	Days 43-49	Days 50-56
Cell Age	0	0	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6								
Shift	7-3	3-11	11-7	7-3	3-11	11-7	7-3	3-11	11-7	7-3	3-11	11-7	7-3	3-11	11-7	7-3	3-11	11-7	7-3	3-11								
Hours from Bath-Up	0	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	236	236	404	572	740	908	1076	1244
Target Pot Voltage (V)	5.24	4.95	4.70	4.70	4.60	4.52	4.46	4.41	4.36	4.32	4.29	4.26	4.23	4.22	4.20	4.18	4.17	4.16	4.15	4.14	4.09	4.09	4.03	4.01	4.01	4.01	4.01	4.01
BRSP (µΩ)	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14
Total new pot RA (µΩ)	2.67	2.04	1.50	1.48	1.28	1.10	0.97	0.85	0.76	0.67	0.59	0.52	0.47	0.45	0.40	0.37	0.34	0.32	0.29	0.28	0.16	0.16	0.04	0.00	0.00	0.00	0.00	0.00
CRSP (µΩ)	7.81	7.18	6.64	6.62	6.42	6.24	6.11	5.99	5.90	5.81	5.73	5.66	5.61	5.59	5.54	5.51	5.48	5.46	5.43	5.42	5.30	5.30	5.18	5.14	5.14	5.14	5.14	5.14
AM Lockout	Remove AM Lockout once voltage is stablized and lower than CRSP and liquid level is in range																											
NC Lockout	Y	Y	Will be removed automatically during Metal Pouring																									
BFT (sec)	17	16	16	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Demand Feed	Enable demand feed along with AM Lockout																											
SFF Dumps	10	10	10	10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
OF Rate (%)	158	149	144	138	139	138	135	133	133	131	130	129	128	128	128	128	127	127	127	127	126	126	125	125	125	125	125	125
UF Rate (%)	33	43	47	53	57	58	61	63	63	65	66	67	68	68	68	68	69	69	69	69	70	70	71	71	71	71	71	71
AE Lockout	Remove AE Lockout along with AM Lockout																											
AE quenching disabled	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AE Dumps	40	35	35	30	30	30	25	25	25	25	25	25	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Near AE Lockout	Remove Near AE Lockout along with AM Lockout																											
NAE quenching disabled	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
NAE Dumps	30	25	25	25	20	20	20	20	20	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Bath Temp (°C)	990		984 - 987			980 - 983			977 - 979			975 - 977			973 - 974			972 - 973			967 - 969	967 - 969	966 - 967	966	966	966	966	966
Bath Temp measurements	Once per shift (to be entered as routine measurements)																					Once per day			Every second day (recheck next day at big deviations)			
Bath Samples	Once per day (morning shifts)																						Once every second day		Once every 4 days (recheck next day)			
Anode CD measurements	Every 4 hours			Set pot curvature by raising anode 10,26,27,28,29 and 30 by 1.5 cm prior to metal pouring - Then Normal Routine MeasurementNormal Routine																								
Liquid Bath addition	10 tons	Adjust if outside range based on 1 cm is equal to 200 kg													Adjust if outside range based on 1 cm is equal to 150 kg									Use normal pot bath tapping table				
Bath Height Generation (cm)	38	38	26			26			22			22			22			22			21	17	17	17	17	17	17	17
#REF!	Add 40 bags (600 kg)	Additional soda based on calculations of AlF3 control logic																										
Xs AlF3 (%)	4.0		4.0			4.0			4 - 4.5			5 - 6			6.5 - 7			7.5			8.5 - 9.5	8.5 - 9.5	9.5	9.5	9.5	9.5	9.5	9.5
AlF3 Lockout	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Remove AlF3 lockout					
Metal addition	-	-	18 tons, using automated Metal Pouring logic after 16 hrs from bath addition (expected metal height is 18 cm)																									
Metal Height (cm)	0	0	18	18	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Metal Tapping						Metal tapping will start from 2nd Metal tapping cycle if metal height is 21 cm or above. Follow metal tapping table for new pot for first 5 cycles and then follow normal cell tapping table.																						
Carbon skim	Y	Y	Carbon skimming from tap hole and duct side before metal transfer																									
Redressing	-	-	-	Redress the pot in the shift after metal pouring with crushed bath to target height of 16 cm. Continue redressing the pot with crushed bath during bath generation (upto 8 days after start up), then redress the pot with 16 cm ACM.																								

POST BATH UP ACTIVITIES

- After start up tilter is removed, carbon dust skimming
- Soda addition is done as per the recommendation
- Keep monitoring the pot voltage and noise level.
- Generally current distribution after bath up is done twice per shift
- Metal addition is to be done after 18-24 hrs to build the metal pad
- In modern technology , voltage of the pot is adjusted automatically while pouring metal
- Pot redressing to be done

Metal pouring is in progress

SUPER HIGH AMPERAGE POTS

- There are four super high amperage technologies (550-660 kA)
- Advantages:-
- Lower capex, faster return on construction cost
- Higher productivity and lower operating cost per ton of metal
- Low specific energy consumption
- Technical studies of MHD, thermoelectric and mechanical modelling indicate, it is possible to operate the prebake cells even at 1000kA

SUPER HIGH AMPERAGE POTS

- Challenges :-
- A major challenge is managing magneto hydrodynamic stability especially the vertical component
- The higher heat input due to high current must be offset by heat dissipation from sides, cathode surface and the top of the anodes.
- Less bath volume is available per kA for dissolving alumina

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Super-High Amperage Prebake Cell Technologies in Operation at Worldwide Aluminum Smelters

Cell Technology	SY-600	NEUI-600	AP-60	RA-550
Technology Provider	SAMI	NEUI	RTA	Rusal ETC
Company	Xinfa Group	Weiqiao	Rio Tinto Alcan	UC Rusal
Location	Liaocheng smelter, Shandong, China	Weiqiao smelter, Shandong, China	Arvida smelter, Jonquière, Quebec, Canada	Sayanogorsk smelter, Russia
Amperage kA	600-660	600	570-600	550
Number of opearting lines	3 lines	3 lines	Demonstration line	Pilot Test group
Number of opearting cells	630	558	38	8-Jan
Year of start up	2015	2014	2013	2016
Production- t Al per pot/day	5	4.6	4.4	4.2
Annual Production kt Al/ pot line	365	309	Unknown	7.6
Annual production kt Al /smelter	1150	900	60	unknown
Current efficiency %	94	94.3	94.6	**94.5**
Cell Voltage (V)	3.85	3.85	4.15	**3.8**
Energy Consumption Mwh/t	12205	12,166	13,072	**12,000**

Super high amperage line in China

Picture 2: Interior View of NEUI600kA Aluminum Reduction Potroom

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Thank you

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