Light Metals 2013 *Edited by: Barry Sadler*
TMS (The Minerals, Metals & Materials Society), 2013

Bevill and the Aluminum Industry

TMS[1], Anthony E. Schoedel[2]
[1]TMS (The Minerals, Metals & Materials Society); 184 Thorn Hill Rd.; Warrendale, PA 15086, USA
[2]Alcoa Inc., 201 Isabella Street, Pittsburgh, PA 15212, USA

Keywords: Bevill, Alumina, Bayer Process

Abstract

This paper serves as both a primer and an update on the Resource Conservation and Recovery Act (RCRA) statutes and regulations affecting the aluminum industry in the USA. Specifically, this paper will discuss the affect the Bevill Amendment to RCRA has and continues to have on the industry, particularly the import, mining, refining and primary production of aluminum. The paper will cover the development of the RCRA regulations vis-à-vis the aforementioned up-stream aluminum production processes up to the most recent court decisions on applicability of rules to certain of the Bevill "high volume, low toxicity wastes".

Introduction

Like many mining and minerals enterprises operating throughout the USA, what remains of the domestic bauxite mining, alumina refining and primary aluminum reduction operations have historically and continue to generate residues and wastewaters in large volumes from its founding in the USA in 1888. During the post-World War II expansion of the manufacturing industries in the USA, handling of wastes generated from these domestic operations (including the aluminum industry) came under increasing scrutiny, all of which culminated in US Congress passing landmark environmental legislation including in 1976 the Resource Conservation and Recovery Act (RCRA)[1]. For the first time in the USA, all "generators" of solid wastes needed to properly classify and manage these solid wastes from cradle to grave. Amended from time to time since 1976[2], RCRA and other environmental legislation and their implementing regulations continue to require due diligence on the part of "generators" to protect human health and the environment as far as solid waste management goes.

The aluminum manufacturing industry did succeed in negotiating exclusion from RCRA requirements – the Bevill Amendment. As discussed below, this amendment excluded "…solid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under Subtitle C of RCRA. The litigation that followed for the next nearly 15+ years honed the scope of that exclusion and along the way left many domestic aluminum operators confused as to what got exempted under Bevill and what did not at any point in time. This paper will briefly discuss the regulatory and legislative history of the Bevill Amendment vis-à-vis the domestic aluminum industry in general and the alumina refining process in particular as well as look at more specific impacts on the operations of perhaps the most widely-used alumina refining process – the Bayer Process.

Bevill Amendment – Regulatory and Legislative History

Like many domestic environmental rules and their application to complex industrial facilities, RCRA and Bevill have consumed considerable professional engineering, legal and other environmental consulting services. The confusion started early in the regulatory process. After the legislative passage of RCRA, the nascent US Environmental Protection Agency (US EPA), less than a decade old at this time, initially proposed implementing regulations (1978 December) which included a "special waste" category[3,4]. The US EPA at the time said the original six (6) wastes and categories to be included in this designation posed little risk to human health or the environment relative to others. During those days on the heels of an energy crisis, the US Congress wanted to show the American people that they didn't want the US EPA to "discourage the use of coal". The late Alabama Representative Tom Bevill spearheaded a movement among his House of Representative colleagues to codify, even temporarily, the "special waste" language from the proposed US EPA regulations into the RCRA act itself. The US Congress passed (and then-President Carter signed into law) the temporary Bevill Amendment[4,14].

As documented in many other sources[1,2,5,6,7,15,16], the Bevill Amendment underwent many years of study, proposed rules, withdrawn proposed rules, litigation, settlements and so on. For the aluminum industry in particular, Bevill initially included the following wastes: primary aluminum carbonaceous wastes (spent potliners), red and brown muds from alumina refining and both fluorogypsum and process wastewaters from the production of hydrofluoric acid (at times manufactured at the same site as bauxite refining into alumina). Eventually the US EPA failed to meet the deadlines for reports required by Bevill and the implementing regulations. As a result, in 1984 *Concerned Citizens* sued US EPA for missing the deadlines to file reports required under RCRA[6]. With new deadlines for reports and regulations, the US EPA again proposed definitions and criteria on which to base those wastes covered by Bevill and again missed the deadlines – another suit followed (this time *Environmental Defense Fund vs. EPA*) and this time the US EPA came through[7]. By 1988 the US EPA finalized its earlier definitions of what constitutes "processing" wastes and high volume, low toxicity for fitting wastes into those categories. For the aluminum industry, spent potliners left the Bevill umbrella (shortly to become K088 listed hazardous wastes) but the other above-mentioned bauxite and alumina wastes got retained; by 1991 red and brown muds as well as the fluorogypsum and process wastewaters from HF acid production got final status under Bevill and codification in the federal hazardous wastes rules as "solid wastes not considered hazardous wastes" at 40 CFR Section 261.4(b)(7)[8,13]. This represented a significant event for the domestic alumina industry (just as it did for the other industries with wastes covered under Bevill) – without this coverage, these wastes generated at a very high volume and lower toxicity than standard RCRA characteristic wastes could from time to time require management under more stringent Subtitle C regulations; rather, now these wastes could get managed all the time under state-passed solid waste regulations at significant cost savings with little additional risk to human health and the environment when managed correctly.

Some key definitions to keep in mind when discussing Bevill and its applicability include:

- Extraction: the initial removal of ore from the earth[3,15];
- Beneficiation: the initial attempt at liberating and concentrating the valuable mineral from the extracted ore[3,15];
- Mineral Processing: processes which generates waste streams that generally bear little or no resemblance to the materials that entered the operation[3,15];
- Uniquely Associated: a notion that any material one wants to claim as covered by Bevill essentially comes from only that process and no other (i.e., red or brown muds, etc.)[9,10];
- Ancillary: for our purposes, materials generated from any operation whether you find it at a mineral processing facility or other facility (i.e., spent solvents, lab wastes, etc.)[9,10].

From a regulatory standpoint, we need to note that several other requirements exist to ensure a plant retains Bevill exclusion for its wastes, including:

- Mixture rule – under this rule if any Bevill-exempt material gets mixed with any hazardous waste, it may become hazardous waste (certain for listed wastes; possible for characteristic wastes)[11];
- Derived from rule – any material derived from a Bevill exempted material (i.e., supernatant from a red mud surface impoundment) itself retains the Bevill exclusion[11].

Let's focus on a specific aluminum process and use these definitions to show their impact vis-à-vis Bevill on on-site operations. Since spent potliners got removed from the definition of mineral processing and since the USA has more active alumina refineries than bauxite mines, we've selected that process (and more specifically, the Bayer Process for alumina refining) for this paper.

Specific Impacts on Alumina Refining

Essentially the same as the first Bayer processing plants from the late 1800's, today's Bayer Process for the refining of bauxite into alumina consists of essentially five (5) steps after mining (see Figure 1 for a simple schematic for the typical Bayer Process)[12]:

- Crushing, grinding, blending, etc.;
- Digestion or Extraction (digestion in this report)
- Filtration or Clarification (clarification in this report);
- Precipitation; and
- Calcination or Drying (calcination in this report).

The first of these – crushing, grinding, blending, etc. – represent operations more correctly covered under beneficiation (see definition above). While some of these same activities occur at the actual mine sites, still more crushing and grinding and removal of non-ore materials (i.e., stumps/other wood material like roots, etc.) needs to occur at the refining sites so as not to un-necessarily clog downstream operations. Typically at alumina refineries you see port facilities for the un-loading of the bauxite ores, large storage piles or structures to store the feed bauxites from different mines and blending equipment – some may also have crushers, grinding equipment, etc. Alumina refineries typically transfer certain amounts of bauxites from each pile (depending on the desired blend) to conveyors which take the blend to the digesters.

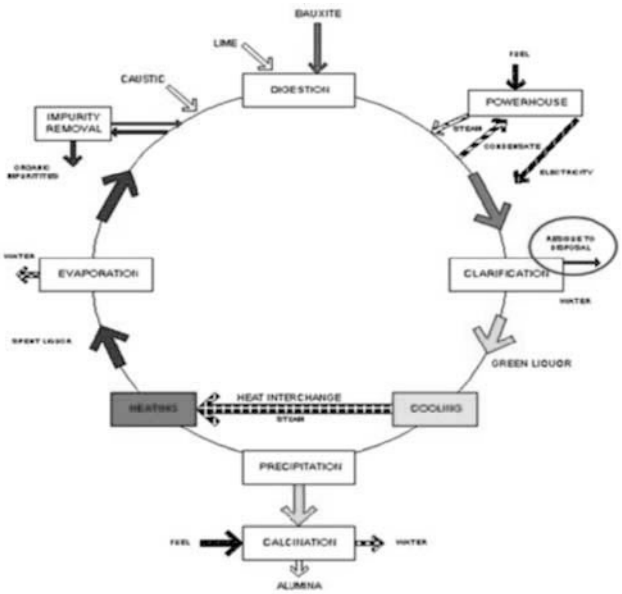
The next step – digestion – usually involves the mixture and batch reaction at an elevated temperature of the bauxite blend and caustic (sodium hydroxide, or NaOH) and other materials to separate the extractable alumina minerals from the bauxite ore. At the elevated temperatures in the digester, the soluble components of the extractable alumina dissolve into the caustic solution and any free alumina (depending upon the temperature of the digester) reacts with the sodium to form sodium aluminate. The resulting mixture or slurry then moves on to the next step in the process – clarification (usually after some stream temperature and pressure modifications).

In clarification, the slurry from the digesters go through a series of settling or thickening steps followed by more filtering to remove as much of the dissolved sodium aluminate as possible from the non-extractable alumina parts of the bauxite (mostly oxides of iron, red in color [hence the name of the mud removed further downstream]). A typical flow would include a series of thickeners for primary settling of the un-dissolved portions of the bauxite remaining; the overflow from those thickeners would continue on to more filters (traditional plate/frame or drum vacuum-type filters) before going off to the next step in the production process – precipitation. The underflow from the thickeners and material removed from the other filters then enter a secondary washing or clarification stage where facilities attempt to recover sodium aluminate and caustic not removed during the primary steps. The end result of these washing steps – red mud that goes typically to on-site surface impoundments for further settling and liquor separation (for eventual return to the processing plant) and supernatant water/caustic which goes into the primary production flow.

The next step – precipitation – involves the art of seeding a tank with a high concentration of sodium aluminate in caustic with particles of alumina to begin the precipitation of the alumina from the liquor. This precipitation usually occurs in a number of continuous cascading precipitation vessels designed to wring out as much alumina as possible. Many other factors play a large part in this art succeeding, not the least of which – temperature of the incoming stream from clarification steps. Temperature plays such an important part in this process that many Bayer Process plants insert a heat exchange operation between the clarification and precipitation processes to optimize the temperature for precipitation as well as effect heat transfer economies. Cooling rate also factors into this "art", affecting particle size, crystalline structure, etc. After further evaporation and solid/liquid separation, the caustic solution then returns to the front of the process at the digestion stage while the alumina then heads to its final step in the Bayer Process – calcination.

Calcination involves the washing and filtering of the alumina (aluminum hydroxide, referred to as alumina "tri-hydrate" in the industry) from the precipitation stage (to remove any free caustic not removed there) followed by heating in a kiln or other high temperature reactor to remove stoichiometric water. This involves the use of a high temperature "calciner" or traditional rotary kiln at a high enough temperature (2000 °F) to drive off the chemically attached water molecules. The result – the white powder known as alumina (or aluminum oxide).

Figure 1 – Typical Simple Schematic – Bayer Process



Typical Bevill and non-Bevill Wastes from an Alumina Refinery

As discussed above, the types of activities typically found at the start of a domestic alumina refinery operating the Bayer Process resemble beneficiation more than mineral processing (see definitions earlier). In fact, though not a confirmation of this in all cases, the US EPA in its 1990 report to Congress[15] identified these activities when conducted before digestion to meet their definition of beneficiation. Typical solid wastes generated at these types of operations include: debris removed from bauxite ore; bauxite ore spills; storm water run-off from the piles, roads, etc. of bauxite storage piles/conveyors, equipment; etc. As a result, any solid wastes generated at these operations would get coverage under the Bevill Amendment and, hence, not require compliance with Subtitle C regulations.

The most important Bevill-related concern in any mining/mineral production facility – do the on-site activities not covered under the beneficiation definition meet any of the narrow mineral processing definitions the industry and the US EPA litigated for over a decade? In order to answer that question, the point between the crushing/grinding/blending operations (the end of beneficiation) and the digestion area of an alumina refinery (the start of processing) must be defined. When looking at the definitions of each process, clearly bauxite looks like bauxite prior to digestion and after digestion no longer has either the same physical or chemical make-up:

- More liquid than solid in appearance
- Higher temperature after digestion than prior
- More caustic (due to digestion in NaOH) during and after than prior

Under this definition, from this point on no wastes generated at the alumina refinery have direct legislative coverage under the Bevill Amendment. In support of this "point" as the end of beneficiation and the start of mineral processing, the US EPA in their 1990 report to the US Congress used this point when discussing the alumina industry[10,16]. As a result, Bayer refinery plant operators must clearly identify the point in the process from where those wastes generated fit the narrow definition of those mineral processing wastes codified at 40 CFR Section 261.4(b)(7) germane to the alumina and bauxite industries (as identified above) using the definitions and principals articulated earlier (i.e., ancillary, derived from and uniquely associated) – no easy task.

Let's start with the easiest – red mud. Clearly included in the approved mineral processing wastes covered under the US EPA regulations implementing Bevill, the term applies to the refuse from the Clarification area where the operator of the Bayer Process has recovered all of the caustic and other valuable minerals (i.e., dissolved alumina) from the filtered mud. At this point, the "high volume, low toxicity" mud (usually pH <13.5, the trigger used by the US EPA for toxicity evaluation under the Bevill regulatory efforts and studies[16]) usually gets pumped to on-site earthen impoundments where solids settle and liquids (with caustic value) either percolate through the accumulated mud or pool on the surface of the accumulated mud. These liquids usually find their way back to the production process in a variety of ways – the key RCRA point: if these liquids have a pH over 12.5 S.U. they still enjoy the Bevill exclusion under the derived from rule (ditto goes for the accumulated mud if used or re-used for other purposes). This same analysis holds for the other Bevill-exempt wastes at times generated at Bayer Process plants – HF acid, gypsum, etc. These materials also usually find themselves accumulated on-site in surface impoundments with some liquids (usually acidic in nature) re-used in the processing plants. These materials, during accumulation and re-use, also enjoy the derived-Bevill from rule benefits.

In both cases, however, problems occur when operators do not distinguish regulatorily between red mud's and those items that look, feel, act, etc. like red mud's – scales, clean-outs from tanks/clarifiers/thickeners, spills/leaks of caustic, etc. Having on-site surface impoundments with miles of piping and the accompanying pumps may tempt operators who need to quickly dispose of similar materials – to comply with these domestic regulations the operators should not send to those surface impoundments any hazardous wastes besides the exempt red mud or those HF/gypsum wastes clearly identified as mineral processing wastes covered under Bevill. As mentioned by the US EPA and others over the years, many items may look, feel and act like these Bevill-excluded wastes but using the ancillary and uniquely associated principals articulated earlier, they do not fit the definition. Examples:

- Scale – not uniquely associated to this operation as many manufacturing sites have scale build-up in pipes, equipment, tanks, etc.;
- Laboratory wastes – an ancillary operation (many manufacturing sites have on-site laboratories – they may not analyze bauxite, alumina, acids/caustic but they "analyze" and, hence, do not qualify as uniquely associated);

- Used acids and/or used caustics – again, many if not all manufacturing operations clean piping, equipment, etc. using these types of chemicals. The "cleaning" operation using these acids/caustic at alumina refineries does not qualify as uniquely associated for this purpose;
- Equipment draining/clean-out – many times equipment will get clogged or fails to operate correctly, necessitating removal from service to repair. To effect the repairs, the contents of the tanks/piping/pumps/etc. need to get removed – while these may have similar properties to those mineral processing wastes covered under Bevill, they do not enjoy coverage under Bevill and must get put back into the process or managed in another way instead of management with the red mud's and the HF/gypsum wastes (not uniquely associated);
- Spills and leaks of caustic/acids – these materials also do not enjoy coverage under the Bevill exclusion for mineral processing as, again, they do not fit the uniquely associated criteria (i.e., these materials act more or less as a solvent for the alumina or other scale compounds in the primary production process – the "solvent" activities occur in almost all manufacturing plants, not only Bayer Process plants so, hence, non coverage under Bevill);
- Organic materials in the bauxite – these materials as well as their downstream reactant (oxalate) compounds developed during the Bayer Process do not enjoy coverage under the Bevill exclusion for mineral processing as, again, they do not fit the uniquely associated criteria.

These types of plants may have other unit operations that generate wastes downstream of the point of demarcation between beneficiation and mineral processing:

- Power generation facilities;
- Shipping/receiving (vessel, rail, highway);
- Maintenance operations;
- Caustic production;
- Trim cooling;
- Lime addition;
- Heat exchange.

In all of these operations, all that occur downstream of the line of demarcation (except possibly the receiving of bauxite ore and other commodities) and do not qualify automatically for coverage under Bevill – each plant operator must evaluate each waste generated from each process individually to ascertain coverage under Bevill.

A few key points of potential pitfalls in operating a Bayer Process in the USA today deserve further discussion.

First – spills and leaks of caustic. Since all of the operating Bayer Process plants in the USA existed prior to RCRA's passage in 1976, it is clear that none of the companies who commissioned these plants built them with RCRA in mind (i.e., sealed, non-leaking tanks, storm sewers, surface impoundments [other than those built or commissioned after 1976], foundations and other structures underlying the tanks, etc.). In addition, most of these facilities are designed to drain caustic materials out of pipes to enable safe maintenance and repair to occur. The drained material may get collected in purpose-built concrete bunkers, storm sewers or other similar structures. Some of these structures have limited ability to return these materials to the production process. Operating this way jeopardizes the Bevill exclusion at the site if any of these drained materials (or spills/leaks) exhibit a hazardous characteristic (i.e., pH>12.5 or metals over TCLP thresholds) as these materials do not qualify as uniquely associated and cannot get mixed with red mud's or the HF/gypsum materials without possibly voiding the Bevill exclusion for the entire waste. Quite a challenge – dealing with aging plants built without RCRA in mind and with Mother Nature acting unpredictably.

Secondly – cleaning with acids and caustics. These materials likewise do not qualify as uniquely associated as they come from a cleaning process (not unique to this industry – though what they clean and how they clean and what they clean with may have some unique nature, the cleaning operation does not qualify as unique). As with the leaks and spills above, these wastes if they have pH measurements over 12.5 or under 2.0 S.U. (and/or other RCRA characteristics) then they cannot get mixed with red mud's or other Bevill-exempt materials without potentially jeopardizing the entire amount of material getting mixed together and managed in on-site impoundments, etc. (see the derived from and mixture rules for Bevill).

Thirdly – process optimization and material recycling and re-use. Processes such as heat exchange, re-use of caustic, recovery of "soda" from surface impoundments and others may cause angst for plant operators striving to attain and retain compliance with RCRA. RCRA does have built in certain limits to which regulators have jurisdiction and site operators need to understand those boundaries (both at the federal and state levels) as they apply to their sites. Outside of those limits (codified at 40 CFR Section 261.2(e) at the federal level), RCRA also gives some limited and narrow allowances for re-use and recycling of materials generated at a Bayer Process plant not covered by Bevill – plant operators can legitimately employ these other exclusions and regulations to their regulatory benefit (though with limited financial benefit) to remain in compliance and avoid costly permits for on-site treatment and accumulation/storage.

Summary

- Long regulatory and legislative history of Bevill Amendment and implementing regulations
- Confusion on what gets covered in the Bayer Process and what doesn't by Bevill exclusion from RCRA

Not just the domestic alumina refining industry but all domestic industries that generate and manage wastes covered by Bevill may well continue to find themselves fighting to save this exclusion from passing the way of the Pony Express. While relatively quiet on the legislative and regulatory fronts since the final LDR issues resolved under AMR II, recent events could result in future efforts to either restrict the scope of Bevill or eliminate it altogether and bring all materials heretofore exempt from full RCRA regulation under its reach. Those recent events include:

- 2008 December 22 TVA ash spill in Roane Co., TN USA;
- 2010 October 04 red mud lake failure at the Ajka Alumina Refinery in Hungary;
- EPA's announced focus on Surface Impoundment Enforcement activities.

We believe that all exempted industries need to ensure that they comply with the limits of these exclusions and exceptions so as not to jeopardize these exceptions and exclusions going forward.

References

1. http://ipmall.info/risk/vol8/summer/brown+.htm
2. http://www.epa.gov/waste/laws-regs/rcrahistory.htm
3. 43 FR 58946 1978 December 18
4. Solid Waste Disposal Act Amendments of 1980 (Pub. L. 96-482), which added §3001(b)(3)(A)(i-iii) (the Bevill Amendment) to RCRA, 1980 October 12
5. http://www.epa.gov/history/origins.htm
6. *Concerned Citizens of Adamstown vs. EPA* No. 84-3041, D.D.C. August 21, 1985
7. *Environmental Defense Fund vs. EPA, 852 F.2d at 1316 [D.C. Cir. 1988], cert denied* 109 S. Ct. 1120 [1989][EDF vs. EPA]
8. 54 FR 15316 1989 September 01
9. See 1999 October 19 letter from US EPA's Elizabeth Cotsworth to Cara Jablon (RCRA On-Line #14523)
10. http://www.epa.gov/compliance/assistance/sectors/minerals/processing/bevilltraining.html
11. 66 FR 50332 2001 October 03 (re-instating mixture and derived-from rules for Bevill-exempt materials
12. Alcoa – Point Comfort Operations, Point Comfort, TX USA
13. 55 FR 22520 1990 June 01
14. 45 FR 33066 and 76618 1980 May 19
15. EPA/530-SW-85-033, December 1985
16. REPORT TO CONGRESS ON SPECIAL WASTES FROM MINERAL PROCESSING – Volume II: Methods and Analyses July 1990