SLAG

V&M STAR

Slag

- **Slag is a byproduct of metal smelting, and hundreds of tons of it are produced annually in the process of refining metals and making alloys.**
- **In appearance, slag looks like a loose collection of aggregate with lumps of varying sizes.**
- **Slag is produced in a number of ways:**
  - Represents undesired impurities in the metals being smelted which float to the top during smelting process.
  - During smelting, metals oxidize and slag forms a protective crust of oxides on the top of the metal being smelted.
- **Common components of slag include:**
  - Silicon oxides
  - Aluminum oxides
  - Magnesium oxides
  - Sulfur oxides
  - Phosphorus
  - Calcium
  - Ash
  - Limestone

Regulatory Status of Slag in U.S.

- **The US Federal Register, Vol. 45, No. 98, May 19, 1980, lists the substances ruled hazardous by the US Environmental Protection Agency (EPA).**
- **US has four major hazardous waste characteristics: Ignitability, Corrosivity, Reactivity, and Toxicity.**
- **Slag was tested by the U.S. EPA and found to be non hazardous:**
  - Retained heat from manufacturing or processing was dropped from the standard to avoid inclusion of slag in the Ignitability hazard class.
  - Corrosivity requirements were changed to only include liquid wastes and the upper pH value raised to 12.5 or more, effectively excluding high pH steel slag from the hazardous classification.
  - Reactivity standards were revised to require that any toxic gases generated must be in 'a quantity sufficient to present a danger to human health or the environment'; slag generates only minute quantities and is therefore exempted.
  - Toxicity requirements set maximum leachate values at 100 times the drinking water standard, far higher than any slag could ever be expected to test.
- **The only furnace-related by-product of the steel industry listed as hazardous is the electric-furnace emission control dust or sludge, based on possible high concentrations of hexavalent chromium, lead, and cadmium.**

Toxicity Characteristic Leaching Procedure (TCLP)

- Designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes.
- Used to determine if a waste meets the definition of EP toxicity, which means it carries a hazardous waste code under RCRA (40 US CFR Part 261) of D004 through D052.
- If a “solid waste” fails the test for one or more of these compounds, the waste is considered to be a characteristic hazardous waste (unless an exemption applies).
- Slag and sludge (which both vary in their components) contain multiple contaminants that require a TCLP.

TCLP: Maximum Concentration of Contaminants for Toxicity Characteristic

EPA Hazardous Waste Code	Contaminant	Regulated Level (mg/l) (or ppm)
D004	Arsenic (As)	5
D005	Barium (Ba)	100
D018	Benzene	0.5
D006	Cadmium (Cd)	1
D019	Carbon Tetrachloride	0.5
D020	Chlordane	0.03
D021	Chlorobenzene	100
D022	Chloroform	6
D007	Chromium (Cr)	5
D023	o-Cresol	200
D024	m-Cresol	200
D025	p-Cresol	200
D026	Cresol	200
D016	2,4-D	10
D027	1,4-Dichlorobenzene	7.5
D028	1,2-Dichloroethane	0.5
D029	1,1-Dichloroethylene	0.7
D030	2,4-Dinitrotoluene	0.13
D012	Endrin	0.02
D031	Heptachlor	0.008

EPA Hazardous Waste Code	Contaminant	Regulated Level (mg/l) (or ppm)
D033	Hexachlorobutadiene	0.5
D034	Hexachloroethane	3
D008	Lead (Pb)	5
D013	Lindane	0.4
D009	Mercury (Hg)	0.2
D014	Methoxychlor	10
D035	Methyl ethyl ketone	200
D036	Nitrobenzene	2
D037	Pentachlorophenol	100
D038	Pyridine	5
D010	Selenium (Se)	1
D011	Silver (Ag)	5
D039	Tetrachloroethylene	0.7
D015	Toxaphene	0.5
D040	Trichloroethylene	0.5
D041	2,4, 5-Trichlorophenol	400
D042	2,4,6-Trichlorophenol	2
D017	2,4,5-TP (Silvex)	1
D043	Vinyl Chloride	0.2

Slag Research[1]

- Over the past several years, the U.S. Steel Slag Coalition ("SSC"), a group of 63 companies that produce steel, process slag, or both, has undertaken a comprehensive study of the chemical composition of slag generated during the steelmaking process and the potential human health and ecological risks associated with possible exposure to such slag.
- Risk assessments developed during 1998 demonstrate that slag poses no meaningful threat to human health or the environment when used in a variety of residential, agricultural, industrial, and construction applications.

Processors of Iron and Steel Slag in the United States

AC Air-cooled blast furnace slag
GG Ground Granulated Blast Furnace Slag
Exp Expanded pelletized blast furnace slag
BOF Basic Oxygen Furnace steel slag.
OHF Open-Hearth Furnace steel slag
EAF Electric Arc Furnace steel slag

Slag processing company	Plant location	State	Steel company serviced	AC	GG	Exp	BOF	OHF	EAF
AMSI	Holsopple	PA	North American Höganäs, Inc.						X
Barfield Enterprises, Inc.	La Place	LA	Bayou Steel Corp.						X
Barfield Enterprises, Inc.	Lone Star	TX	Lone Star Steel Corp.						X
Beaver Valley Slag	Aliquippa	PA	Old slag pile site	X				X	
Beaver Valley Slag (Thor Mill)	Roanoke	VA	Roanoke Electric Steel, Inc.						X
Blackheart Slag Co.	Muscatine (Montpelier)	IA	IPSCO Steel, Inc.						X
Border Steel, Inc.	El Paso	TX	Border Steel, Inc.						X
Buffalo Crushed Stone, Inc.	Woodlawn	NY	Old slag pile site	X					
Buzzi Unicem USA, Inc.	New Orleans	LA	Various foreign		X				
Civil & Marine, Inc.	Cape Canaveral	FL	Various foreign		X				
Edward C. Levy Co.	Decatur (Trinity)	AL	Nucor Steel Corp.						X
Edward C. Levy Co.	Butler	IN	Steel Dynamics Inc.						X
Edward C. Levy Co.	Columbia City	IN	Steel Dynamics Inc.						X
Edward C. Levy Co.	Crawfordsville	IN	Nucor Steel Corp.						X
Edward C. Levy Co.	Detroit	MI	Severstal North America, Inc.	X			X		
Edward C. Levy Co.	Detroit	MI	U.S. Steel Corp.	X			X		
Edward C. Levy Co.	Canton	OH	The Timken Co.						X
Edward C. Levy Co.	Delta	OH	North Star-Bluescope Steel Inc.						X
Edward C. Levy Co.	Huger	SC	Nucor Steel Corp.						X
Essroc Corp.	Middlebranch	OH	Miscellaneous domestic and foreign		X				
Florida Rock Industries, Inc.	Tampa	FL	Various foreign		X				

Processors of Iron and Steel Slag in the United States (Cont.)

AC — Air-cooled blast furnace slag
GG — Ground Granulated Blast Furnace Slag
Exp — Expanded pelletized blast furnace slag
BOF — Basic Oxygen Furnace steel slag.
OHF — Open-Hearth Furnace steel slag
EAF — Electric Arc Furnace steel slag

Slag processing company	Plant location	State	Steel company serviced	AC	GG	Exp	BOF	OHF	EAF
Fritz Enterprises, Inc.	Fairfield	AL	U.S. Steel LLC	X			X		
Gerdau Ameristeel Corp.	Jacksonville	FL	Gerdau Ameristeel Corp.						X
Gerdau Ameristeel Corp.	Charlotte	NC	Gerdau Ameristeel Corp.						X
Glens Falls-Lehigh Cement Co.	Cementon	NY	Various foreign		X				
Holcim (US) Inc.	Birmingham (Fairfield)	AL	U.S. Steel LLC		X				
Holcim (US) Inc.	Gary	IN	U.S. Steel LLC		X				
Holcim (US) Inc.	Weirton	WV	Weirton Steel Corp.		X				
Lafarge North America Inc.	Chicago	IL	Ispat Inland Steel, Inc.		X				
Lafarge North America Inc.	Joppa	IL	Ispat Inland Steel, Inc.		X				
Lafarge North America Inc.	East Chicago	IN	Ispat Inland Steel, Inc.			X			
Lafarge North America Inc.	Sparrows Point	MD	International Steel Group Inc.		X				
Lafarge North America Inc.	Cleveland (Cuyahoga Co.)	OH	International Steel Group Inc.	X					
Lafarge North America Inc.	Lordstown	OH	Old slag pile site		X				
Lafarge North America Inc.	McDonald	OH	Youngstown Sheet and Tube Co.	X					
Lafarge North America Inc.	Salt Springs (Youngstown)	OH	Youngstown Sheet and Tube Co.	X					
Lafarge North America Inc.	Warren	OH	WCI Steel Inc.	X					
Lafarge North America Inc.	West Mifflin	PA	U.S. Steel LLC (ET Works)	X					
Lafarge North America Inc.	West Mifflin (Brown Reserve)	PA	Old slag pile site	X					
Lafarge North America Inc.	Whitehall	PA	Various foreign		X				
Lafarge North America Inc.	Seattle	WA	Various foreign		X				
Lafarge North America Inc.	Weirton	WV	Weirton Steel Corp.	X					
Lehigh Cement	Evansville	PA	Various foreign		X				
Levy Co., Inc., The	Burns Harbor	IN	International Steel Group Inc.	X			X		

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AC	Air-cooled blast furnace slag	BOF	Basic Oxygen Furnace steel slag.
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Exp	Expanded pelletized blast furnace slag	EAF	Electric Arc Furnace steel slag

Slag processing company	Plant location	State	Steel company serviced	AC	GG	Exp	BOF	OHF	EAF
Levy Co., Inc., The	East Chicago	IN	International Steel Group Inc.	X					
Levy Co., Inc., The	Gary	IN	U.S. Steel LLC	X	X				
Mountain Enterprises, Inc.	Ashland	KY	AK Steel Corp.	X					
MultiServ	Birmingham	AL	Structural Metals Corp.						X
MultiServ	Tuscaloosa	AL	Nucor Steel Corp.						X
MultiServ	Blytheville	AR	Nucor Steel Corp.						X
MultiServ	Blytheville (Armorel)	AR	Nucor-Yamato Steel Co.						X
MultiServ	Pueblo	CO	Rocky Mountain Steel Mills						X
MultiServ	Wilton (Muscatine)	IA	IPSCO Steel, Inc.						X
MultiServ	East Chicago	IN	Ispat Inland Steel, Inc.				X		
MultiServ	Indiana Harbor	IN	International Steel Group Inc.				X		
MultiServ	Ghent	KY	Gallatin Steel Co.						X
MultiServ	Sparrows Point	MD	International Steel Group Inc.	X			X		
MultiServ	Ahoskie (Cofield)	NC	Nucor Steel Corp.						X
MultiServ	Canton	OH	Republic Engineered Products LLC						X
MultiServ	Mansfield	OH	AK Steel Corp.				X		
MultiServ	Warren	OH	WCI Steel Inc.				X		
MultiServ	Braddock (Mon Valley)	PA	U.S. Steel/Republic Technologies				X		
MultiServ	Butler	PA	AK Steel Corp.						X
MultiServ	Coatesville	PA	International Steel Group Inc.						X
MultiServ	Koppel	PA	Koppel Steel Co. (NS Group, Inc.)						X

Processors of Iron and Steel Slag in the United States (Cont.)

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Slag processing company	Plant location	State	Steel company serviced	AC	GG	Exp	BOF	OHF	EAF
MultiServ	Steelton	PA	International Steel Group Inc.						X
MultiServ	Midlothian	TX	TXI Chaparral Steel Co.						X
MultiServ	Geneva (Provo)	UT	Geneva Steel Holdings Corp.6	X			X		
MultiServ	Seattle	WA	Nucor Steel Corp.						X
Rinker Materials Corp.	Miami	FL	Various foreign		X				
St. Lawrence Cement, Inc.	Camden	NJ	Various foreign		X				
St. Marys Cement, Inc.	Detroit	MI	Various foreign		X				
Stein, Inc.	Sterling	IL	Sterling Steel, Inc.						X
Stein, Inc.	Ashland	KY	AK Steel Corp.	X			X		
Stein, Inc.	Cleveland	OH	International Steel Group Inc.	X			X		
Stein, Inc.	Loraine	OH	Republic Engineered Products LLC	X			X		
Titan Florida, Inc.	Medley	FL	Various foreign		X				
Tube City IMS Corp.	Birmingham	AL	Nucor Steel Corp.						X
Tube City IMS Corp.	Newport	AR	Arkansas Steel Assoc.						X
Tube City IMS Corp.	Rancho Cucamonga	CA	TAMCO Steel						X
Tube City IMS Corp.	Portage	IN	Beta Steel Corp.						X
Tube City IMS Corp.	Norfolk	NE	Nucor Steel Corp.						X
Tube City IMS Corp.	Perth Amboy	NJ	Gerdau Ameristeel Corp.						X
Tube City IMS Corp.	Sayreville	NJ	Gerdau Ameristeel Corp.						X
Tube City IMS Corp.	Middletown	OH	AK Steel Corp.	X			X		
Tube City IMS Corp.	Mingo Junction	OH	Wheeling Pittsburgh Steel Corp.	X			X		

Processors of Iron and Steel Slag in the United States (Cont.)

AC	Air-cooled blast furnace slag	BOF	Basic Oxygen Furnace steel slag.
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Exp	Expanded pelletized blast furnace slag	EAF	Electric Arc Furnace steel slag

Slag processing company	Plant location	State	Steel company serviced	AC	GG	Exp	BOF	OHF	EAF
Tube City IMS Corp.	Youngstown	OH	V&M Star (North Star, Inc.)						X
Tube City IMS Corp.	Sand Springs	OK	Sheffield Steel Corp.						X
Tube City IMS Corp.	Cayce	SC	SMI/CMC Steel Group						X
Tube City IMS Corp.	Knoxville	TN	Gerdau Ameristeel Corp.						X
Tube City IMS Corp.	Seguin	TX	SMI/CMC Steel Group						X
Tube City IMS Corp.	Petersburg	VA	TXI Chaparral Steel Co.						X
Tube City-IMS, IMS Division	Axis	AL	IPSCO Steel, Inc.						X
Tube City-IMS, IMS Division	Fort Smith	AR	Macsteel						X
Tube City-IMS, IMS Division	Newport	AR	Arkansas Steel Assoc.						X
Tube City-IMS, IMS Division	Kingman	AZ	North Star Steel Inc.						X
Tube City-IMS, IMS Division	Claymont	DE	CitiSteel USA, Inc.						X
Tube City-IMS, IMS Division	Cartersville	GA	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Wilton (Muscatine)	IA	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Kankakee	IL	Nucor Steel Corp.						X
Tube City-IMS, IMS Division	Peoria	IL	Keystone Steel & Wire Co.						X
Tube City-IMS, IMS Division	Laplace	LA	Bayou Steel Corp.						X
Tube City-IMS, IMS Division	Jackson	MI	Macsteel						X
Tube City-IMS, IMS Division	Monroe	MI	Macsteel (Quanex)						X
Tube City-IMS, IMS Division	St. Paul	MN	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Jackson	MS	Nucor Steel Corp.						X
Tube City-IMS, IMS Division	Charlotte	NC	Gerdau Ameristeel Corp.						X

Processors of Iron and Steel Slag in the United States (Cont.)

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Exp	Expanded pelletized blast furnace slag	EAF	Electric Arc Furnace steel slag

Slag processing company	Plant location	State	Steel company serviced	AC	GG	Exp	BOF	OHF	EAF
Tube City-IMS, IMS Division	Perth Amboy	NJ	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Sayreville	NJ	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Auburn	NY	Nucor Steel Corp.						X
Tube City-IMS, IMS Division	Marion	OH	Marion Steel Co.						X
Tube City-IMS, IMS Division	McMinnville	OR	Cascade Steel Rolling Mills, Inc.						X
Tube City-IMS, IMS Division	Portland	OR	Oregon Steel Mills Inc.						X
Tube City-IMS, IMS Division	Bethlehem	PA	Old slag pile site	X			X		
Tube City-IMS, IMS Division	Bridgeville	PA	Universal Stainless & Alloy Products Inc.						X
Tube City-IMS, IMS Division	Midland	PA	J&L Specialty Products, Inc.						X
Tube City-IMS, IMS Division	Monroeville	PA	Old slag pile site					X	
Tube City-IMS, IMS Division	New Castle	PA	Ellwood Quality Steels Co.						X
Tube City-IMS, IMS Division	Park Hill (Johnstown)	PA	Old slag pile site				X		
Tube City-IMS, IMS Division	Pricedale	PA	Old slag pile site				X		
Tube City-IMS, IMS Division	Reading	PA	Carpenter Technology Corp.						X
Tube City-IMS, IMS Division	Darlington	SC	Nucor Steel Corp.						X
Tube City-IMS, IMS Division	Georgetown	SC	Georgetown Steel Corp.						X
Tube City-IMS, IMS Division	Jackson	TN	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Beaumont	TX	Gerdau Ameristeel Corp.						X
Tube City-IMS, IMS Division	Jewett	TX	Nucor Steel Corp.						X
Tube City-IMS, IMS Division	Longview	TX	LeTourneau Steel Group						X
Tube City-IMS, IMS Division	Plymouth	UT	Nucor Steel Corp.						X
Tube City-IMS, IMS Division	Saukville	WI	Charter Steel						X
Tube City-IMS, IMS Division	Weirton	WV	Weirton Steel Corp.				X		

Slag Use in U.S.

- In 1997, iron and steel slag consumption totaled approximately 21.4 million tons valued at about $147 million.
- Of this total, BF slag accounted for approximately 65 percent of the tonnage and was worth about $118 million.
- Steel slag accounted for the remainder.
- The physical shape of slag particles make steelmaking slag a superior material for use as a construction aggregate, currently the major use of steelmaking slag.
- Natural aggregates, such as limestone, sand, and gravel products, compete with slag for use as a construction aggregate.
- Because slag is a renewable mineral resource, its use reduces the consumption of natural resources by the construction industry.

Slag Use in US (continued)

- **Major uses of steelmaking slag:**
  - Aggregate in bituminous mixes such as: pavement surfaces, bases, surface treatments, seal coats, slurry coats, and cold patch.
  - Concrete aggregate and as an ingredient in cement
  - Anti-skid aggregate (snow and ice control aggregate)
  - Surfacing of stabilized shoulders, banks and other select material
  - Bank stabilization (erosion control aggregate)
  - Gabions and riprap
  - Aggregate base courses and sub-bases
  - Unpaved driveways, surface roads, and walkways
  - Mineral wool (home and appliance insulation)
  - Railroad ballast
  - Neutralization of mine drainage and industrial discharge
  - Agricultural uses, such as soil remineralization and conditioning, pH supplement/liming agent, fertilizer
  - Controlled, granular fills, such as those for unpaved parking and storage areas, pipe and tank backfill, berm construction, and other industrial and construction activity
  - Construction aggregate or a fluxing agent at steel mills
  - Landfill daily cover material
  - Landscape aggregate
  - Trench aggregate/drain fields
  - Sand blast grit
  - Roofing granules
  - Bulk filler (e.g., paints, plastics, adhesives)

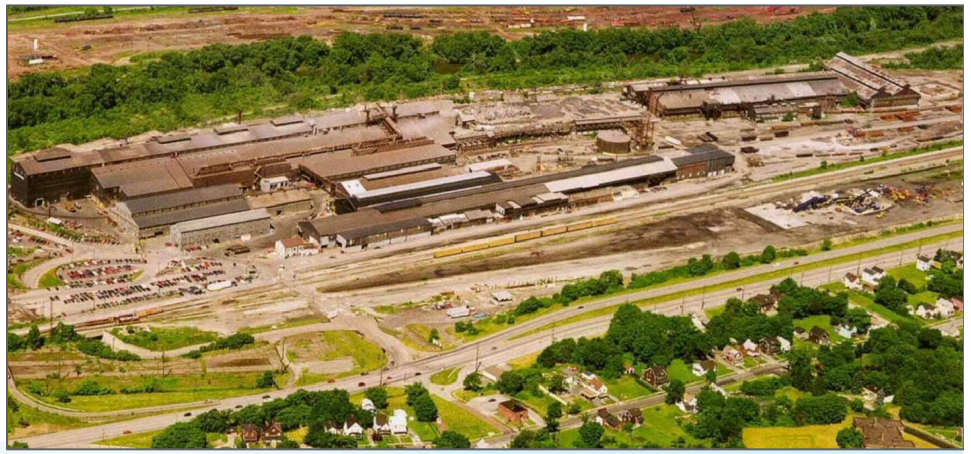
Youngstown, Ohio

The V&M - Youngstown facility includes:

- An 85-ton electric arc furnace;
- A 3-strand continuous caster of 8 3/4" or 11 1/4" rounds;
- A walking beam reheat furnace; and
- A 6-stand retained mandrel mill (MPM).

Site Statistics

- 27.05 acres owned
- 112.93 acres leased
- 29.2 acres under roof



V&M STAR
Youngstown, OH

- Mini-mill with a 830,000 short ton per year capacity.
- Produce high quality seamless steel pipe for the oil and gas industries.
- Annual output capacity is approximately 610,000 tons of finished tubular products, of which 66% are Oil Country Tubular Goods (OCTG).
- Produced approximately 34,744 tons of slag in 2009, which is sold to a third part for processing.
- Slag produced per month is approximately 10-12% of liquid steel tons.

Slag Processing

- Tube City IMS serves as the third part processor for the V&M STAR Youngstown facility.
- After slag is poured off EAF it is transported to a cooling pit and watering area.
- The slag is then sorted, all large pieces of steel are removed with a magnetic crane, and then run through a separator which sorts the slag according to sizes.
- The sized slag is then sold to outside companies for many different applications.
- All slag processed is sold to an outside company, no waste is generated.
- At V&M STAR the mTon of Slag per mTon of Liquid Steel Produced = .12

3RD PARTY SLAG SALES - 2009

9-Jan	2,191 tons
Robert Janson	637
Foster Trucking	512
Youngstown Iron	250
Lakeside	210

9-Feb	2,216 tons
Murphy Trucking	551
Foster Trucking	253
Ray Brothers	229
Rt#5 Sand & Gravel	212

9-Mar	6,051 tons
Ray Brothers	1,491
Murphy Trucking	1,361
Rt#5 Sand & Gravel	405
JDS Landscape	374
Gwinn Brothers	325
Simak	309

9-Apr	4,076 tons
Ray Brothers	818
Don Kennedy	817
Murphy Trucking	217
NJM Excavating	176
Rt#5 Sand & Gravel	134

9-May	2,414 tons
Ray Brothers	296
Gwinn Brothers	282
Rt#5 Sand & Gravel	202
Murphy Trucking	170

9-Jun	3,099 tons
Ray Brothers	651
Gwinn Brothers	498
Rt#5 Sand & Gravel	253
Murphy Trucking	124

TOTAL TONS FOR 2009 = 34,744

9-Jul	1,163 tons
Gwinn Brothers	238
Murphy Trucking	123
Ray Brothers	113

9-Aug	2,767 tons
Youngstown Iron	320
Ray Brothers	292
Larson Trucking	265
Lee Gardner	172
Simak Trucking	170
Robert Janson	124

9-Sep	2,279 tons
Gwinn Brothers	827
Ray Brothers	500
Simak Trucking	250
Robert Janson	153

9-Oct	2,912 tons
Youngstown Iron	826
Gwinn Brothers	738
Ray Brothers	451
JDS Landscaping	148
Robert Janson	102

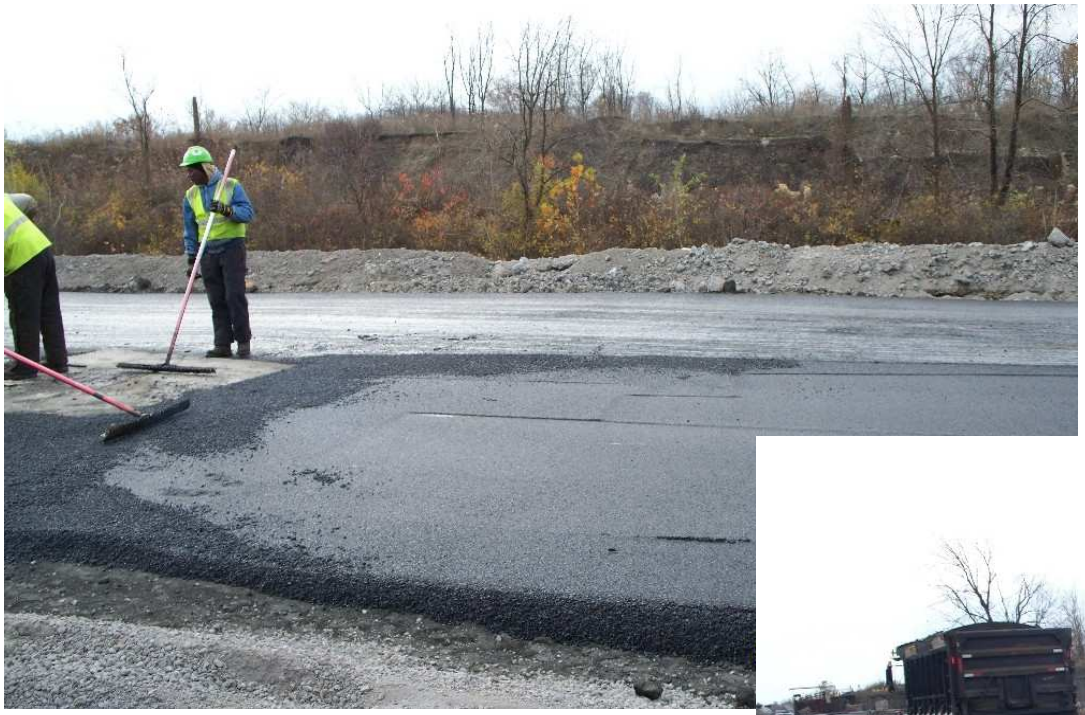
9-Nov	3,961 tons
Total Waste Logistics	1,419
Ray Brothers	691
Gwinn Brothers	355
Simak Trucking	307
Robert Janson	288

9-Dec	1,615 tons
Gwinn Brothers	532
Simak Trucking	301
Ray Brothers	262
Youngstown Iron	250

2008 Pilot Study

- V & M Star pilot study to reduce waste and increase recycling efforts was successfully completed in 2008.
- Ohio EPA was involved in and approved of pilot study.
- Waste streams (mill scale and sludge) that are generated during production of seamless pipe were incorporated into a road base material.
- The objectives of the pilot study included: providing sufficient strength to support heavy equipment, flexibility to prevent cracking, durability for long service life, and stability to bind and secure any residual metals, oil, and/or grease present in the mill scale and sludge.
- Waste streams were mixed with fly ash, steel furnace slag, and cement to create a strong base material to use during road improvement operations within the facility.
- Since the pilot study, a 600 foot section of this road base material was utilized at the Youngstown facility.
- V&M STAR Environmental Department has requested continued installation of the road base material throughout the plant in upcoming years as a feasible alternative to off-site disposal, potentially increasing the average waste recycling rate to greater than 90%.

2008 Pilot Study (cont.)



Slag roadway installation

2008 Pilot Study (cont.)

Completed slag roadway

Sludge Pad

Awards

- V&M STAR Ohio received the 2009 Steel Manufactures Association Recycling Award for the road way project.

- Additionally, the facility is in the final selection process for the Ohio Environmental Stewardship Award.

Comparison of V&M Slag Analytical to Regulated Level (ppm)

	2010 Analytical	Regulated Level
Arsenic	ND	5
Barium	.266	100
Cadmium	ND	1
Lead	ND	5
Selenium	ND	1
Silver	ND	5

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For More Information:

- National Slag Association http://www.nationalslag.org/
- Slag Cement Association
  http://www.slagcement.org/
- American Iron and Steel Institute
  http://www.steel.org//AM/Template.cfm?Section=Home
- The Steel Manufactures Association
  http://www.steelnet.org/

References

1. Information developed by the National Slag Association – Environmental Committee