0050591

S

STA. 19

MAR 0 2 1998

ENGINEERING DATA TRANSMITTAL

Page 1 of

1. EDT 621537

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Facility Cleanup Projects	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Spent Nuclear Fuel Projects	6. Design Authority/ Design Agent/Cog. Engr.: D. R. Precechtel	7. Purchase Order No.: N/A
8. Originator Remarks: For approval and release. This report documents an alternative conditioning process for K-Basins sludge.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks: 11A. Design Baseline Document? [] Yes [X] No		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-2280		0	Alternative Conditioning Process for K-Basins Sludge	N/A	1,2	1	/

16. KEY

Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
1 2	1	Design Authority D. R. Precechtel X3-85 D.R. Precechtel 2/24/98	3		J. E. Turnbaugh X3-79 J E Turnbaugh 2/25/98
		Design Agent	3		Project Files X3-85
		Cog.Eng.			
1 2	1	Cog. Mgr. C. J. Alderman X3-85 C J Alderman 2/25/98			
		QA			
		Safety			
		Env.			

18.	19.	20.	21. DOE APPROVAL (if required)
D.R. Precechel 2/24/98 D.R. Precechel Signature of EDT Originator Date	Authorized Representative for Receiving Organization Date	C J Alderman 2/25/98 Design Authority/ Cognizant Manager Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

BD-7400-172-1

Alternative Conditioning Process for K-Basins Sludge

D. R. Precechtel
J. E. Turnbaugh
DE&S Hanford, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: ~~634932~~ 621537 UC: 600
Org Code: 2T154 Charge Code: LD254
B&R Code: EW7040000 Total Pages: 51

Key Words: Spent Nuclear Fuel, K-Basin Sludge, Sludge Conditioning, Alternative Process

Abstract: This report documents an evaluation of a proposed alternative sludge conditioning process, based on high-energy milling of K-Basins sludge. High-energy milling K-Basins sludge, in conjunction with solvent extraction of polychlorinated biphenyls (PCBs), appears to be a viable process for preparing for storage in the Tank Waste Remediation System (TWRS) Double Shelled Tanks (DSTs). This report is submitted to provide technical information which could be used in the project baseline decisions.

SWECO is a registered trademark of a division of Emerson Electric Co.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

MAR 02 1998
DATE
STA: 19
HANFORD RELEASE
ID 18

Barbara Shultz 3/2/98
Release Approval Date Release Stamp

Approved for Public Release

HNF-2280 Rev 0

TABLE OF CONTENT

1.0 INTRODUCTION 1

2.0 EXECUTIVE SUMMARY 1

3.0 PROCESS DEVELOPMENT 1
3.1 Process Flow Diagram 2
3.2 Offgas Control System 4
3.3 Processing Throughput Rate 5

4.0 REQUIREMENTS AND ASSUMPTIONS 5
4.1 TWRS Acceptance Criteria 6
4.2 Air Emission Requirements 6
4.3 Process Criticality Safety 6
4.4 Operational Safety 7
4.5 ALARA and Shielding 7

5.0 IDENTIFICATION OF ASSUMPTIONS AND UNCERTAINTIES 7
5.1 Assumptions 7
5.2 Uncertainties 8

6.0 COST AND SCHEDULE 8
6.1 Estimated Cost 8
6.2 Schedule 11

APPENDIX A A-1
APPENDIX B B-1
APPENDIX C C-1

FIGURES

Figure 1. Process Flow Sheet 3
Figure 2. Revised Cost Estimate for the Milling Process 9
Figure 3. Cost Estimate Details 10

TABLES

Table I. How the Milling Process Would Meet TWR Acceptance Criteria 6

ALTERNATIVE CONDITIONING PROCESS FOR K-BASINS SLUDGE

1.0 INTRODUCTION

Conditioning of the K-Basins sludge to meet TWRS acceptance criteria is a critical element of the SNFP plan to place the sludge in safe storage and clean out the K-Basins. A chemical process (Chang 1997) for sludge conditioning was originally proposed as the baseline process. An alternative process, based on high-energy milling of the sludge, has also been proposed (Turnbaugh 1997) that could offer cost, schedule, safety and feasibility advantages over the chemical process.

This paper outlines the application of high-energy milling to K-basins sludge conditioning and describes some of its characteristics. The process is presented here in essentially conceptual form only, with little detailed supporting data, because of the short time allotted to its preparation. More time and effort are necessary to gather additional design information and laboratory proof-of-principle data to better define the process.

Sludge particle size reduction by milling has been considered previously (Precechtel 1997) as a component of sludge conditioning. The study, however, did not include high-energy milling of the type proposed in this paper that also promotes oxidation and stabilization of the reactive sludge constituents.

2.0 EXECUTIVE SUMMARY

High-energy milling of K-Basins sludge, in conjunction with solvent extraction of Poly-Chlorinated Bi-phenyls (PCBs), appears to be a viable process for preparing sludge for storage in the Tank Waste Remediation System (TWRS) Double-Shelled Tanks (DSTs). The reactive milling process could stabilize reactive sludge components to eliminate pyrophoricity and gas generation, reduce particle size to sub-critical dimensions and homogeneously combine neutron absorbers. The flexibility in throughput rates assures that the sludge conditioning schedule could be met.

Relative to the chemical baseline process, the milling process could cost some $8M less, would use no hazardous acids or caustics, produce no acid gases and produce no significant secondary waste streams other than a solvent stream containing PCBs. The actual project savings would be approximately $6M, rather than $8M however, because $2M are already committed in FY98 for the baseline chemical process.

3.0 PROCESS DEVELOPMENT

The goal of sludge conditioning is to meet the TWRS acceptance criteria in a cost-effective, timely, safe and regulatorily-compliant manner. High-energy reactive milling of the sludge slurry as it comes from the K-basins, in conjunction with solvent extraction of PCBs, is a process that should successfully prepare the sludge for TWRS acceptance. High-energy milling is a

widely-used, well established unit process in the ceramics, powder metallurgy and pharmaceutical industries for preparation of fine-particle size slurries and powders and for accomplishing powder/liquid reactions. PCBs will be removed by a solvent extraction system based on well-established, standard technology.

3.1 Process Flow Diagram

The proposed milling conditioning process is illustrated in the process flow diagram of Figure 1 and vendor equipment literature is included in Appendix A.

Sludge will be pumped as a water slurry from the basins into a transport vehicle for delivery to the conditioning facility (assumed to be the CVDF) where it will be unloaded into a surge tank. From the surge tank, the slurry will be fed to the SWECO D-70 vibratory mill (SWECO) where it will be milled and homogeneously blended for a period of time with a neutron absorber (e.g. iron or depleted uranium oxide) and a PCB extraction solvent mixture.

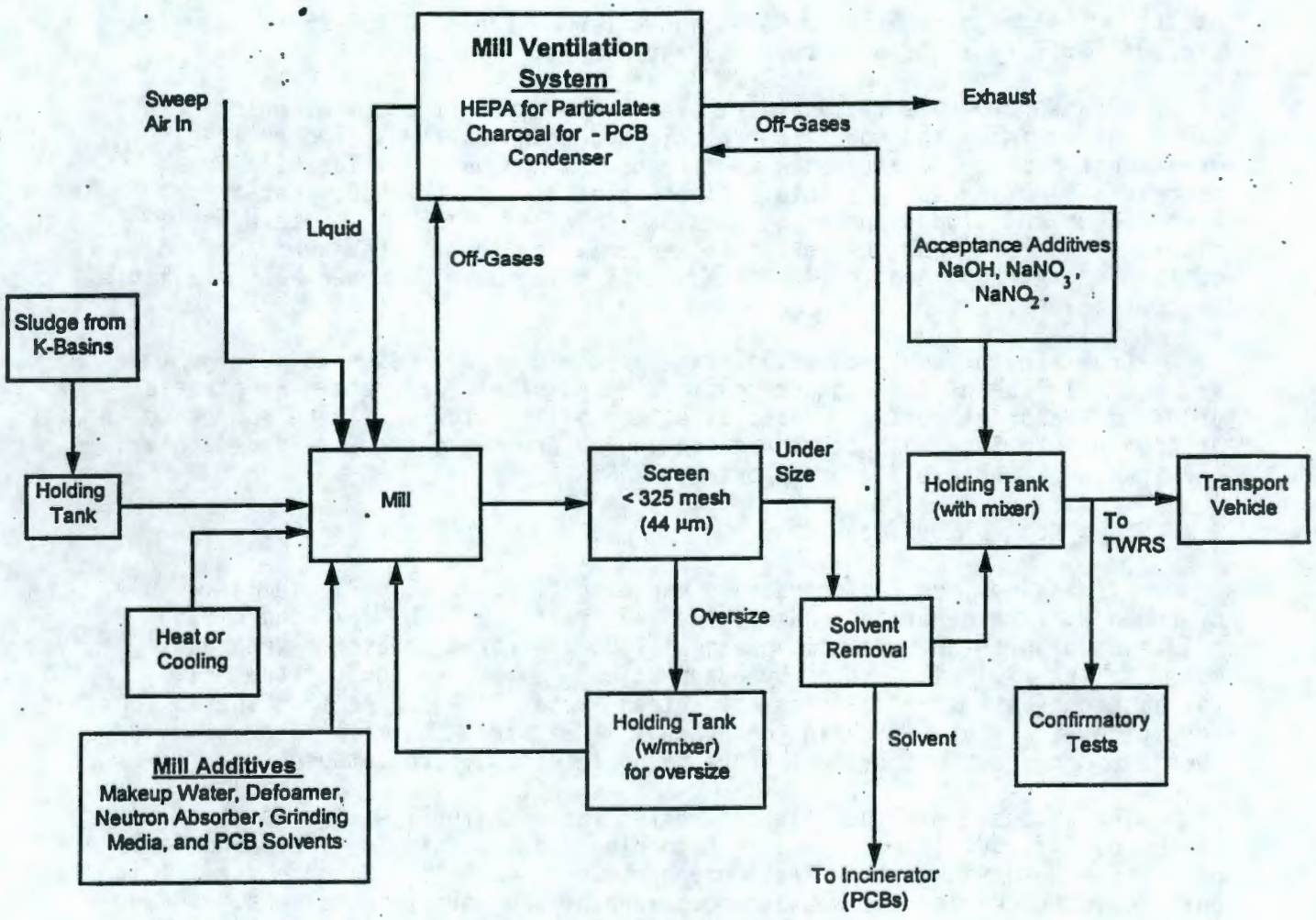
Milling will reduce the sludge particle size and, in the process of adding mechanical energy in the form of increased particle specific surface area and strain and fracture energy, will rapidly react metallic uranium or uranium hydrides with the slurry water to form stable hydrated oxides. The brittle alumina/silicate zeolite ion exchange beads should be as easily milled as the other inorganic, brittle sludge components. A choice of hard, wear-resistant milling media is readily available, including alumina, zirconia and silicon carbide. All of these media are harder than the sludge components and should be easily capable of grinding them without excessive wear. Steel grinding media is also available if it would be advantageous for criticality control.

The mill will be equipped with a cooling jacket to remove excess heat produced by the mechanical energy of grinding and heat of oxidation of the un-reacted uranium. The mass of the mill and its grinding medium (16,000 pounds) will moderate transient temperature rises if a slug of un-reacted uranium is encountered. The temperature can be further controlled by varying the mill feed rate or adding cooling water to the mill feed stream.

From the mill, the slurry will pass through a 325-mesh screen (44-micron openings). Over-sized sludge particles (cladding, larger pieces of uranium, tramp metals and perhaps some organic resin beads) that were not fully milled in the first pass through the mill will be returned from the screen to the mill. The oversized pieces can thus be recycled through the mill until they are small enough to pass through the screen.

From the screen, the milled slurry will enter the solvent removal stage (Schmidt 1998) where the solvent containing the PCBs will be separated from the slurry. The solvent wastestream might designate as a TRU waste. Several possible storage or disposal pathways for the PCB-containing solvent wastestream must be explored. Off-site PCB-approved incinerators are located

Figure 1. Process Flow Sheet



at the DOE sites of INEEL and Oak Ridge. The Hanford CWC PCB-approved waste storage facility might also be a storage possibility.

PCBs should be effectively removed by the solvent combination of methyl ethyl ketone (MEK) and normal parrafinic hydrocarbons (NPH) (Zacher 1998). Mr. Zacher's process discussion is attached as Appendix B. The milling process will bring the MEK into intimate contact with the PCBs that are absorbed on the sludge and resin bead particles. The MEK is expected to displace the PCBs from the particles and transfer them to the NPH. Breakdown of the Ion Exchange Module (IXM) beads will make their absorbed PCBs available to the solvent.

From the solvent separation stage, the slurry will pass to a surge tank where it will be held for adjustment of pH and nitrite/nitrate concentration prior to transport to TWRS. Samples of the milled slurry will be subjected to an appropriate level of acceptance testing before the slurry is loaded into the transport vehicle for transport to TWRS.

3.2 Offgas Control System

Offgassing from the process is expected to be relatively minimal. Some hydrogen will be generated and krypton and tritium will be released due to oxidation of uranium. No acid gases will be generated. Some solvent and water in the mill will escape by evaporation and be swept out by the mill ventilation system. Additional solvent and water will escape from the solvent removal system that will join the exhaust stream from the mill to be treated by the process exhaust system before being released to the atmosphere.

The proposed mill ventilation system (Schmidt 1998) will consist of a series of individual unit operations to clean the air stream. For a nominal offgas control system, the first component would be a liquid condenser. This unit would be chilled and would remove much of the entrained solvent, PCB and water vapor. In addition to removing liquid and condensible vapors from the offgas, this unit would also remove most of the larger particulates (> 1 μm). The condensate could be returned to the process upstream of the solvent separation step, avoiding the generation of a secondary waste stream.

A High Efficiency Mist Eliminator (HEME) would follow the condenser. HEMEs are standard offgas treatment unit operations in radioactive waste vitrification plants used for the removal of condensed-phase submicron mists and aerosols. This unit would provide a ^{137}Cs Decontamination Factor (DF) of approximately 100. Since PCBs will be in a condensed phase, a similar DF might be achieved.

If a water spray is used to continuously clean the filter elements in the HEME, this stream can also be returned to the process upstream of the solvent separation step. Upon leaving the HEME, the offgas would either be diluted or heated above its dew point before it is passed through a High Efficiency Particulate Air (HEPA filter). The HEPA filter will serve to remove all of the remaining small particulates (i.e., ~99.95% removal of 0.3μm

aerosol). It is unlikely significant PCBs will pass through the HEPA filter; DFs of 100,000 for ^{137}Cs are achievable.

After passing through the HEPA filter, it is likely that the offgas can be released to the atmosphere; however, an optional carbon filter can be included in the process exhaust system to further polish the offgas stream to ensure that no PCBs or organics leave the system.

3.3 Processing Throughput Rate

The milling process would operate continuously for two nine-hour shifts per day, so that with the SWECO D-70 mill and a four-hour mill retention time, all the sludge from both basins (ca. 58,000 gal) can be processed in approximately 150 days, not counting down-time. This processing rate assumes that the PCB solvent extraction process will be sized to match the rest of the system so the mill will be the rate-limiting stage. Appendix C describes the estimation of processing rates for the mill.

With simple maintenance, both the SWECO mill and the SWECO screener can be expected from industry experience to run for years without serious breakdown. The DM-70 mill is a ruggedly-build unit with a 40-hp electric motor that is lubricated with a circulating oil system. Maintenance consists of occasionally changing the oil and the oil filter. The motor can be shielded or removed from the radiation field, if radiation damage is considered to be a problem. The screener is equally rugged and is designed for continuous service with routine replacement of screens as they wear.

Downtime of the processing system would probably depend more on the reliability of the incidental equipment such as controls, pumps, valves, feeders and heaters than on the major pieces of equipment. An operating efficiency of 80 percent (downtime of 20 percent) should be achievable for the milling and PCB removal systems. At an operating efficiency of 80 percent, 150/0.8 = 188 days would be required to process all the sludge. The milling throughput rate could be increased, if necessary, by adding additional equipment, shortening the process retention time, adding a third shift or adding a sludge thickening step to reduce the volume of sludge to be processed.

4.0 REQUIREMENTS AND ASSUMPTIONS

The sludge conditioning process must produce a product that will meet the TWRS acceptance criteria, meet state and federal air emissions regulations, be critically and operationally safe and achieve ALARA radiation levels. Key process assumptions and uncertainties that will have to be addressed must be identified.

4.1 TWRS Acceptance Criteria

Table I summarizes how the milling process can meet TWRS acceptance criteria for the sludge.

Table I -- How the Milling Process Would Meet TWRS Acceptance Criteria

TWRS Requirement	Criteria	How Criteria will be Met
Prevent tank (DST) corrosion	pH>12 for $[NO_2^-]$<=1.0M; 0.01M<=[OH]<=5.0M & 0.011M<=$[NO_2^-]$<=5.5M	Hydroxide, nitrite and nitrate will be added to the processed slurry to meet these criteria
Criticality Safety	Particle size <50 microns for fissiles and poison	Milled sludge particles will be screened to <44 microns. Smaller particles can be achieved with longer mill retention times. Neutron absorbers such as oxides of iron or depleted uranium can be homogeneously blended by co-grinding to the same particle size as the sludge.
	U-235<0.84wt%	Iron/total U mass ratio will be > 0.54 (for U-235=1.25%).
TWRS Retrieval compatibility	Particle size <177 microns	Sludge will be screened to insure particle size <44 microns
Eliminate non-radiolytic gas generation	Tank liquid Sp. gr. x solids depth <150	The milling process will not increase the sludge solids volume, except for the added volume of neutron absorber.
	Commingled Sp.gr. <1.41	The specific gravity of the sludge slurry as received from the basins will not be significantly changed by the milling process.
Eliminate reactive (pyrophoric) materials	No net exotherms	Reactive metals and hydrides will be oxidized and in thermodynamic equilibrium with the slurry
Remove/destroy PCBs	<2ppm/congener in solids, <3ppb in supernate	Milling-enhanced solvent extraction is proposed as the first choice for a PCB removal process.

4.2 Air Emission Requirements

The offgas control system will provide best available technology for removing solvent vapors and aerosols and radioactive airborne particulates from the process exhaust stream as required by state and federal regulations. Monitoring of the exhaust stream will be provided as required. The pollutant of most concern is the PCBs which will be removed by absorption on activated charcoal.

4.3 Process Criticality Safety

Criticality safety will be achieved by control of batch size and geometry. The SWECO mill geometry will assist in assuring criticality safety because it is annular in shape, with an in internal diameter of approximately 29 inches.

4.4 Operational Safety

The proposed process poses no unusual additional operational safety hazards. The milling process is a relatively straight-forward, room temperature, easily controlled mechanical process that uses no acids or caustics. The solvent PCB-extraction process employs flammable solvents which will require an explosion-proof environment. Radiation is the major hazard and it will be abated with shielding and distance.

4.5 ALARA and Shielding

The system will be designed with shielding to minimize radiation exposure to workers, comply with 10 CFR 835, Occupational Radiation Protection and operate in a radiation zone under contaminated conditions. ALARA practices will be used in all maintenance activities. Processing equipment will be modified to operate remotely and in a radiation environment where necessary.

5.0 IDENTIFICATION OF ASSUMPTIONS AND UNCERTAINTIES

This section identifies some of the process assumptions and uncertainties that must be studied and resolved to further develop the process.

5.1 Assumptions

1. Milling will reduce all sludge components (cladding, tramp metals, IXM beads, Graf-foil seals, etc.) to pass a 44-micron screen.

2. Metallic uranium (and perhaps the zircalloy cladding) will be completely oxidized to a stable, non-reactive form.

3. Oxidation of the metals in the mill will be controllable and not result in a "runaway" condition.

4. Added neutron absorbers will be homogeneously blended with the fissile material.

5. Addition of MEK/NPH mixed solvent to the mill can strip PCBs from the sludge and milled IXM bead particles to meet TSCA PCB limits.

6. The only secondary waste streams will be the PCB-containing MEK/NPH and offgas control system filters. All the sludge constituents will be reduced in the mill to pass through the 44-micron screen and be shipped to TWRS.

7. The milling process is scalable; i.e., the laboratory results can be applied reliably, at least with respect to particle size reduction, to predict the results that will be achieved in the larger mill.

8. Shielding adequate to meet ALARA requirements can be accomplished by enclosing equipment rather than using a hot cell.

5.2 Uncertainties

1. The application of high-energy milling to sludge conditioning is new to Hanford (and perhaps to the SNF program) and therefore might not have the "comfort factor" of other alternatives for which there is more local experience.

2. Questions of DST criticality safety based on sludge particle size and homogeneity might require additional analysis. A criticality safety analysis must be prepared to objectively determine whether 44-micron and smaller milled particles blended with neutron absorber materials is safe.

3. Uranium oxidation rate results from lab-scale experiments might not be directly scalable to the full-size mill.

6.0 COST AND SCHEDULE

The method used to estimate the cost and schedule for the baseline chemical sludge conditioning process was also used as a basis for estimating the cost of the milling process. New estimates (Precechtel 1998) for equipment and construction cost for the milling process were developed. Other costs, common to both the chemical and milling processes were unchanged.

6.1 Estimated Cost

The Sludge Removal System baseline budget and schedule was used as the starting point for estimating the costs associated with the high-energy milling process as many of the basic cost elements are common to both alternatives. Where the knowledge base for the milling process were well understood, costs were revised. Any process cost elements that where identified as needed by both processes but with limited knowledge base, the estimate was not changed.

The preconceptual design report (Chang 1997) for the chemical process included cost estimates for equipment and construction. These estimates were prepared by Fluor Daniel Northwest, Inc. for budgeting purposes and were used as input to establishing the overall subproject baseline.

The cost of the Sludge Removal Project (WBS 1.3.1.1.50) with the chemical process was estimated in June 1997 to be $56.8M (Figure 2). This cost includes $27.3M for design and construction of the chemical sludge conditioning subproject and $5.5M for process development. The June 1997 subproject estimate utilized fiscal year 1997 dollars which assumed no escalation. In addition, it did not use FY98 project overhead rates.

Figure 2. Revised Cost Estimate for the Milling Process

K BASINS PROJECTS

SPENT NUCLEAR FUEL PROJECTS

SLUDGE REMOVAL

1.3.1.1.50

	FY98	FY99	FY00	FY01	FY02	FY03	CHEM TOTAL	MILL TOTAL
Project Management	785	770	800	800	455	101	3,711	3,711
Sludge Conditioning System Development	2500	2171 1620	1086 750	308 525	54 80		5,475	3,619
KE Sludge Retrieval System	910	1335					2,245	2,245
KW Sludge Retrieval/ Loadout System		199	218	2659	185		3,348	3,348
KE Loadout System	50	249	1885	1042	560		4,141	4,141
TWRS Receiving Station	100	50	1196	422	373		2,141	2,141
Transportation System			235	1075	750		2,060	2,060
Sludge Conditioning System		400 525	8284 10768	7842 10200	4499 5835		27,328	21,025
Sludge Removal Operations	0	0	1225	1491	0	3462	6,378	6,378
CHEM TOTALS	4,345	4,748	17,077	18,234	8,238	3,763	56,827	
MILL TOTALS	4,345	5,174	14,929	15,659	6,876	3,763		50,746

A NATIONAL ASSET

SLUDGEDRAFT-February 1998-nfp

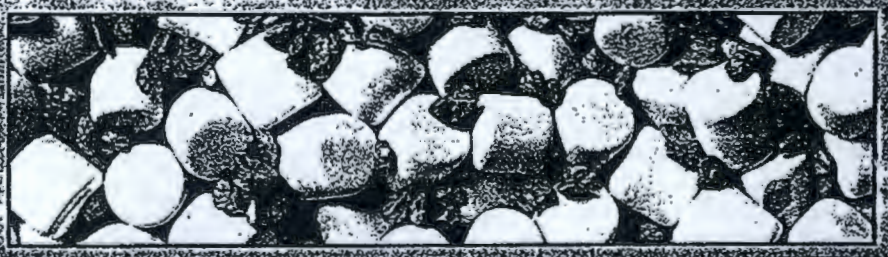
Figure 3. Cost Estimate Details
(Milling Process)

Activity	Estimated Value $(k)	Basis of estimate
Initiate Testing	310	Change request SNF-97-048, PCB Treatment Testing -Surrogate testing (cold test) $50k, - Hot cell testing $260k
Prepare definitive design	2446	o Title II Design -35% of construction (note 1) - $1232k o Title III Design -15% of construction (note 1) -$528k o Plus 30% for site adder - $528k (note 7) o $158k allowance to accommodate review comment for redundant equip. design
Prepare Safety documentation	2250	o Prelim Safety Assessment (note 6) -$500k o CSER (note 6) - $100k o SAR mod. (note 6) - $525k
Fabricate Equipment	8383	o Procurement (note 2) - $5290k o Site adder at 30% (note 7) - $1587k o Additional $1409 for redundant equipment (note 3) o Misc. allowance $97k (note 6)
Construct and install	6879	o Construction (note 4) - $3520k o Site adder at 30% (note 7) - $1056 o Shielding material and I&C for redundant equipment - $1864k (note 5), use 80% of base o Labor for above shielding and I&C equipment Installation -$439k (note 6)
ATPs/OTPs & Startup	757	From past experience 11% of construction
Total	21025	

Notes 1-Based on estimate contained in HNF-SD-PCR-002, Rev. 0, "Pre-conceptual Design Report, K Basins Sludge Pretreatment System. " FDNWR04, page 5, includes 50% contingency.
2 Based on above report, contains 35% contingency
3 Per design review comment, system required additional redundancy, see HNF-SD-SNF-DRR-012 for specific comment, based on PCR-002 equipment estimate , FDNWR05, page 6, contains 35% contingency.
4 Based on PCR-002, construction estimate, FDNWR02, page 2, contains 50% contingency
5 Based on design review comment from note 3, shielding material, labor, I&C allowance for additional process skid.
6 Based on engineering judgment to complete Safety documentation. For the mill process use 2 times the base estimate.
7 The 30% Site adder includes G&A/SWS @ 13.9%, MPR @ 7%, and escalation of 5.4%.
An additional 4% was also included from past experiences in working in the basins

SWECO

VIBRO-ENERGY® GRINDING MILLS



D.E.ROGERS COMPANY
"QUALITY PROCESS EQUIPMENT"
P.O. Box 3397
Redmond, WA 98073
(206) 885-0554 • fax: 868-6972

FOR WET OR DRY GRANULAR TO SUB-MICRON PARTICLE SIZE REDUCTION

SWECO®

Therefore, it does not exactly reflect the current baseline budget but is used for relative cost comparison between the chemical and milling processes.

The preconceptual design estimate addressed a single process train only, with no redundancy. Additional costs for redundancy were included in response to comments received during a review of the estimate. The other milling process sub-project costs shown on Figure 2 are estimated to be approximately the same as for the chemical process alternative.

The new cost estimate for the milling process sub-project was developed by revising the two sub-project elements described above. Equipment and construction costs related to the milling process were identified and the existing chemical process cost estimate adjusted in the appropriate areas. The new estimated equipment and construction sub-project cost for the milling process is $21M, and the cost for the milling process development is $3.6M as shown on Figure 3.

The estimated cost of the milling alternative is thus found to be $6M less than that of the baseline chemical process.

6.2 Schedule

Sludge conditioning is scheduled to take place during an approximately ten-month period of time following fuel removal from the basins. The processing throughput rate flexibility of the milling process assures that the sludge processing schedule can be met.

7.0 CONCLUSION

High-energy milling followed by screening is a standard industrial unit process that appears to be a viable, cost-effective alternative for K-basins sludge conditioning. It potentially offers cost and safety advantages because it is relatively simple, uses modified mechanical equipment and does not employ dangerous, difficult to handle chemicals. The milling process appears to be compatible with, and might enhance, the solvent extraction process for removal of PCBs. The only secondary waste streams generated are PCB-containing solvent and disposable exhaust ventilation filters.

8.0 REFERENCES

Chang 1997, *Preconceptual Design Report, K Basins Sludge Removal Sludge Pretreatment System*, HNF-SD-SNF-PCR-002 REV. 0

Turnbaugh 1997, J.E. Turnbaugh, DESH, *Personal Communication to C. Alderman*

Precechtel 1997, *Evaluation of Process for Sludge Particle Size Reduction*, HNF-SD-SNF-TI-051, REV. 0

Precechtel 1998, D.R. Precechtel, DESH, *Personal Communication to J.E. Turnbaugh*

SWECO, SWECO, Inc., Florence, KY

Zacher 1998, A.H. Zacher, PNNL, *Personal Communication to D. Precechtal*

Schmidt 1998, A.J. Schmidt, PNNL, *Personal Communication to D. Precechtal*

APPENDIX A - Vendor Literature

APPENDIX B - PCB Extraction Process

APPENDIX C - Mill Throughput Calculations

HNF-2290 Rev 0

APPENDIX A

VENDOR LITERATURE

DE&S Hanford, Inc.
A Duke Engineering & Services Company

P.O. Box 350
Richland, WA 99352

February 19, 1998

John Altmix, Director of Marketing
SWECO
7120 New Buffington Road
Florence, KY 41042

REQUEST FOR PERMISSION TO REPRODUCE CATALOG PAGES

Dear Mr. Altmix:

As Mr. Jerry Turnbaugh explained in his telephone conversation with you on February 17, 1998, permission is requested to include copies of pages from two SWECO product catalogs in a proposal on processing spent nuclear fuel sludges.

If the statement below is acceptable, please sign it and FAX it to me at (509) 376-7230.

Very truly yours,

Peter G LeRoy

P. G. LeRoy, Director
Environmental Safety and Health
Spent Nuclear Fuel Project

pld

"SWECO hereby grants permission to DE&S Hanford to reproduce pages from the following SWECO product catalogs:

SWECO Vibro-Energy Grinding Mills (GM901 1M NQ 1990) and
SWECO Vibro-Energy Separators (S901 3M NQ 4/95)".

(signed) John Altmix date 2/20/98

SWECO

VIBRO-ENERGY® GRINDING MILLS

D.E.ROGERS COMPANY
"QUALITY PROCESS EQUIPMENT"
P.O. Box 3397
Redmond, WA 98073
(206) 885-0554 • fax: 868-6972

FOR WET OR DRY GRANULAR TO SUB-MICRON PARTICLE SIZE REDUCTION

SWECO®

FAST, LOW-COST PARTICLE SIZE REDUCTION TO SUB-MICRON RANGE

SWECO Vibro-Energy Grinding Mills. The most versatile line of mills available today. Wet or dry grinding. With or without particle-size classification. Closed or open-circuit processing. From small lab batches to full production grinding.

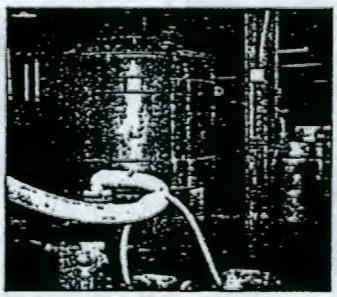
Grinding mills with working capacities as small as 1 pint, and as large as 182 gallons. And for dry grinding, chamber capacities up to 70 cu. ft.

The key feature of every SWECO Grinding Mill is its Vibro-Energy motion. A three-dimensional vibratory action, this precise, high-frequency motion, is the reason why SWECO Mills can grind a greater variety of materials to a particle size of 1/2 micron or less ... with results so consistent that batch time guess work is virtually eliminated.

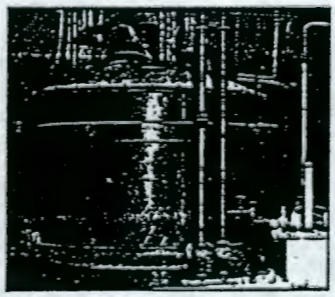
With Vibro-Energy motion, product contamination from media and lining wear is minimized. In addition, SWECO Mills require less energy input than conventional mills of similar capacity.

Since only a minimum of vibration is transmitted to the base of the mill, no special flooring or foundation is required. In addition, maintenance costs are reduced, as there are few moving parts, and replaceable linings are made of abrasion resistant materials.

Four M80 Vibro-Energy Mills grind abrasive materials at the Norton Company, Worcester, Mass.



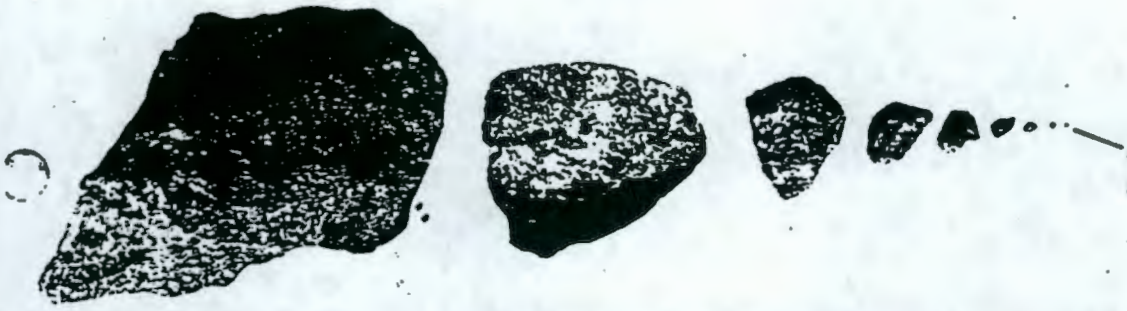
M80 Vibro-Energy Mill grinding frit at a midwestern plant producing ceramic materials.



M80 Vibro-Energy Mill grinds ceramic materials at a large midwestern manufacturing plant.

M45 Vibro-Energy Mill efficiently reduces size of materials used in manufacturing tiny ferrite memory cores at Burroughs Corporation.

The product shown on the front cover is for graphic demonstration only.



A tiny particle of this size - can be ground into 12,812,904 pieces.

High Grinding Efficiency. The high frequency, low amplitude motion, as employed in the Vibro-Energy Mill, is the most effective method of converting energy to accomplish particle size reduction from 100-micron to submicron range.

Uniform Particle Size Distribution. The ability to control particle size precisely is very important in most industries processing finely ground materials. The Vibro-Energy Mill is unequaled in this important aspect of grinding technology. The use of alumina cylinders coupled with this unique motion can provide a uniform particle size and distribution.

Lowest Material Contamination. Contamination of materials while grinding is an important consideration in many industries. Due to the rapid wear of the grinding media in ball or pebble mills, these machines cannot be used in many applications. In contrast, Vibro-Energy Mills introduce negligible media and lining contamination, due to the small impact forces generated.

Reduced Electrostatic Charging or Agglomeration During Grinding. Pigments produced by precipitation and filtration frequently acquire electrostatic charges during the process. These charges bond the pigment particles very tightly, slowing down conventional grinders. The high frequency impacts in a Vibro-Energy Mill quickly dissipate the small static charges originally existing in the pigment.

Requires Less Energy Input. The movement of media in a Vibro-Energy Mill is very small, so a high percentage of the energy is directed into the grinding effort. Once the motion generator is up to operating speed, the inertia of the rotating eccentric weights greatly reduces the power input required to maintain this speed. Consequently, very low energy input is required per unit of ground product produced.

No Special Installation. Unlike conventional ball and pebble mills, the Vibro-Energy Mill does not require deep, heavy concrete foundations, or specially reinforced structures. The major vibrating forces are directed to the grinding chamber with a minimum of vibration transmitted to the base. This results in a substantial savings in installation costs.

Low Maintenance Cost. The inside surfaces of the grinding vessel are constructed of abrasion-resistant polyurethane, with other linings available for special applications. This feature, combined with few moving parts in the mill, significantly reduces maintenance costs.

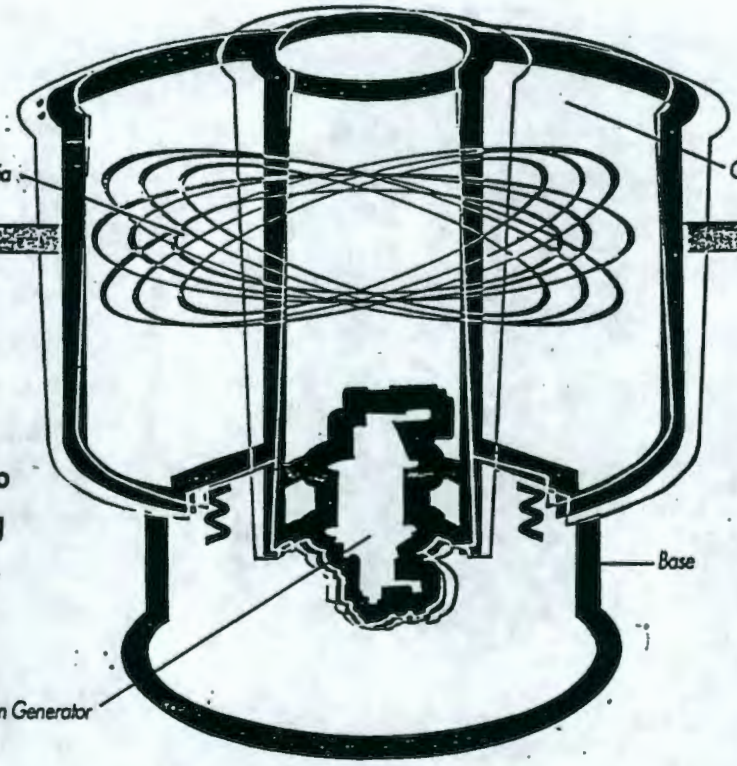
Vibro-Energy Mills are Versatile. SWECO Grinding Mills can easily be operated in series for continuous processing. The units can be used in either open-circuit or closed-circuit grinding.

Temperature Control. Although temperature rise in the Grinding Mill is much more limited than in ball or pebble mills, provisions can be made in some models for effective temperature control to heat or cool the charge material.

Ease of Sampling and Discharge. Because of the unique vibratory motion, discharge of material from the Vibro-Energy Mill is accomplished rapidly and easily while the unit is in operation. Even thixotropic materials flow readily. Samples may be taken by merely opening the valve while the mill continues to operate.

USER ADVANTAGES

Narrow particle size distribution is attained by point, line and face contact of cylindrically shaped grinding media.



VIBRO-ENERGY SOLVES TWO BASIC GRINDING PROBLEMS

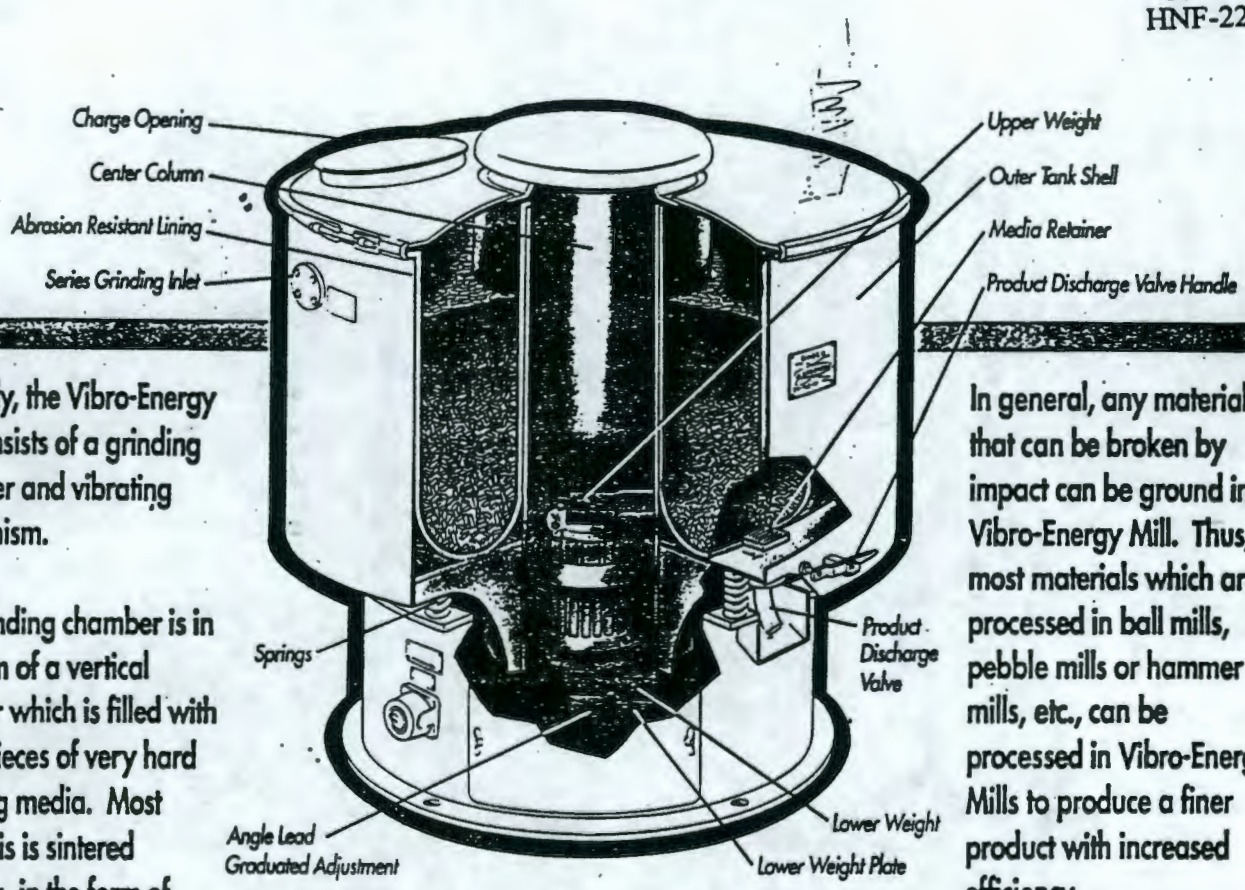
Two basic limitations are inherent in conventional milling systems. These limitations are, first, the inability of these systems to perform ultra-fine grinding economically and, second, their failure to produce uniform particle size distribution.

The Vibro-Energy principle of applying high frequency, three dimensional vibration to a chamber containing small cylindrical grinding media helps to overcome both of these limitations.

It takes less total energy to reduce or break a small particle than it does a large one. For ultra-fine grinding, only very small impact forces are necessary. Any force in excess of that needed to break the material results in wasted energy which will be dissipated as heat. In addition, the greater the number of grinding impacts per unit of time, the faster a given particle size reduction can be accomplished. Therefore, the Vibro-Energy Grinding Mill, using small amounts of energy with high-frequency vibration, is more efficient than the high-impact, low-frequency principle applied in conventional grinding systems.

In most industries which process finely ground materials, uniform particle size is of utmost importance. However, this close particle size distribution has been extremely difficult to achieve with ball and pebble mills. In the lower micron range, their point contact offers decreasing probability of further particle reduction and increasing probability of wide particle size distribution.

The use of cylindrical grinding media, coupled with the unique Vibro-Energy motion, enables SWECO Mills to achieve a narrow particle size distribution. The Vibro-Energy Mill normally uses small alumina cylinders designed to achieve a combination of point, line and face contact. When two pieces of cylindrical grinding media are vibrating against each other, the large particles will be worked on first, and reduced in size, while the smaller particles will remain protected. When the larger particles are reduced, by the combination of point, line and face contact, to the same size as the smaller ones, close particle size distribution has been achieved. Further size reduction maintains this same close range.



HOW THE VIBRO-ENERGY MILL WORKS

Basically, the Vibro-Energy Mill consists of a grinding chamber and vibrating mechanism.

The grinding chamber is in the form of a vertical cylinder which is filled with small pieces of very hard grinding media. Most often this is sintered alumina, in the form of half-inch cylinders. The material to be ground is introduced into the voids between the grinding media. The vibration mechanism is attached directly to the base of the grinding chamber. The whole assembly is suspended on high-tensile steel springs. Thus, all the energy from the vibrating mechanism is imparted directly to the grinding media without the necessity for intermediate gears, drives or clutches.

The vibrating mechanism consists of a specially designed electric motion generator having a heavy shaft mounted in heavy-duty bearings. At each end of the shaft are attached "out-of-bolance" weights. The top weight, which is in the same horizontal plane as the top of the suspension springs, is connected to the motion generator shaft in a fixed position.

The top eccentric weight causes a horizontal gyration of the grinding chamber, while the bottom eccentric weight provides a gyrating tilt. This unique motion causes three dimensional, high-frequency vibration, which constitutes the transfer agent converting the motive energy into grinding impacts.

In general, any material that can be broken by impact can be ground in a Vibro-Energy Mill. Thus, most materials which are processed in ball mills, pebble mills or hammer mills, etc., can be processed in Vibro-Energy Mills to produce a finer product with increased efficiency.

The major benefit derived from Vibro-Energy is its ability to give SWECO Grinding Mills their extraordinarily high-degree of sophisticated chamber movement. Unlike competitive systems, SWECO Grinding Mills feature precise control, dust-free operation, and virtually no transmitted vibration to the floor.

THE COMPLETE LINE OF SWECO VIBRO-ENERGY GRINDING MILLS

DRY GRINDING/CLASSIFICATION SYSTEM WITH SEPARATOR

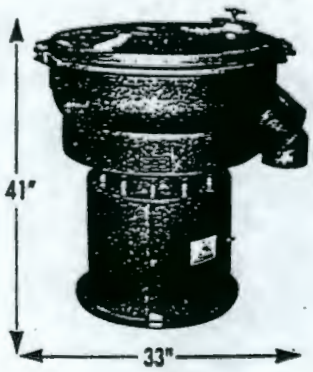
This system incorporates a High Amplitude Grinding Mill, a SWECO Separator, bucket elevator, and control panel. It has been designed especially for processing chemicals, ceramic materials, metallic minerals, for recovering casting sand, and for reclaiming green powdered metal parts.

Approximate chamber capacities: Choice of 3, 10, 20 and 70 cubic feet.

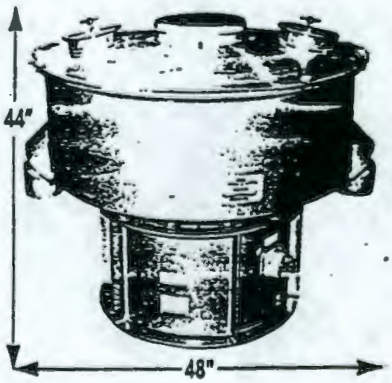
DM1 High Amplitude Grinding Mill
Approximate chamber capacity is 1.2 cubic feet. Lining: 1" cast polyurethane. One cast polyurethane discharge door, including media retainer. Polycarbonate cover secured to chamber by quick release clamp ring. Motion generator: 1/3 HP. Shipping weight: 220 lbs. Normal media load: 80 lbs.

Motion Generator options for all models: 230, 460 or 575 volt, 60 cycle, 3-phase, 1200 RPM, 1/4 HP, TENV. U.L. Approved Motion Generator for Hazardous Location, Class I, Group D, and Class II, Groups F and G, also available.

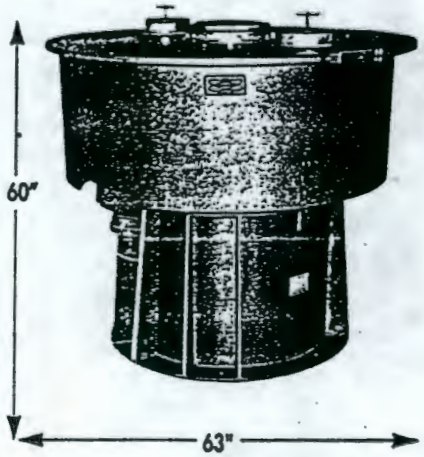
DM3 High Amplitude Grinding Mill
Approximate chamber capacity is 3 cubic feet. Lining: 5/16" cast polyurethane elastomer. One perforated plate discharge door. One metal cover secured by clamp ring and equipped with one charge port. Motion generator: 1 1/4 HP. Linings also available in ceramic and stainless steel. Shipping weight: 475 lbs. Normal media load: 300 lbs.



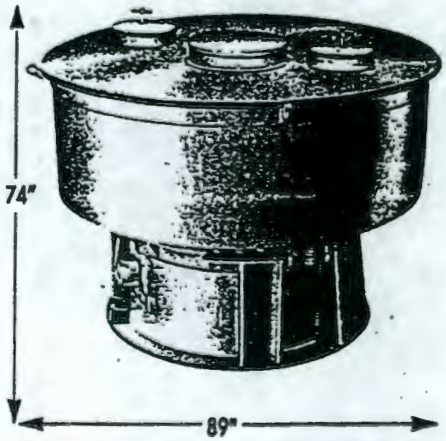
DM10 High Amplitude Grinding Mill
Approximate chamber capacity is 10 cubic feet. Lining: 3/4" cast polyurethane elastomer. Two perforated plate discharge doors located 180° apart. One metal cover secured with clamp ring and equipped with two charge ports. Motion generator: 5 HP. Lining also available in alumina ceramic. Shipping weight: 1,100 lbs. Normal media load: 1,000 lbs.



DM20 High Amplitude Grinding Mill
Approximate chamber capacity is 20 cubic feet. Lining: 3/4" cast polyurethane elastomer. Two air operated discharge doors located 180° apart. One metal cover secured with clamp ring and equipped with two charge ports. Motion generator: 10 HP. Shipping weight: 2,700 lbs. Normal media load: 2,000 lbs.



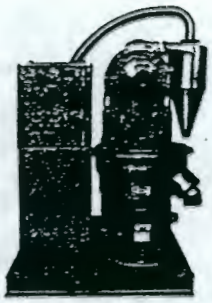
DM70 High Amplitude Grinding Mill
Approximate chamber capacity is 70 cubic feet. Lining: 1" cast polyurethane elastomer. Two air operated discharge doors located 180° apart. One metal cover bolted on and equipped with three charge ports. Motion generator: 40 HP. Lubrication system and control panel provide complete motion generator protection. Lining also available in alumina ceramic. Shipping weight: 9,000 lbs. Normal media load: 7,000 lbs.



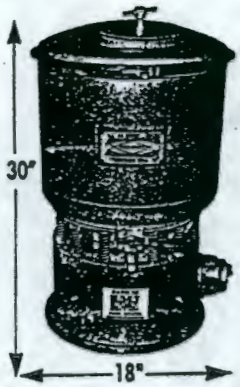
DRY GRINDING/CLASSIFICATION SYSTEM
Dry grind, pneumatically transport, classify and collect materials within one integral system. This system consists of a High Amplitude Grinding Mill, a Turbo-Screen® and a cyclone arranged on a skid for closed-circuit grinding.

It easily processes particle sizes ranging from 250-20 microns. It also handles electrostatic materials. In fact, the system is ideally suited for any application requiring efficient particle size reduction, combined with positive, exact finished product screening — foods, chemicals, plastics and ceramics, for example.

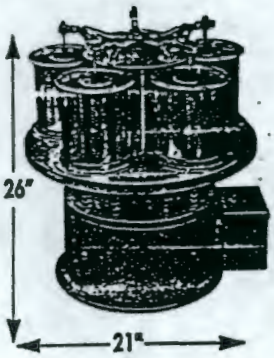
Approximate chamber capacities: Choice of 3, 10, 20 and 70 cubic feet.



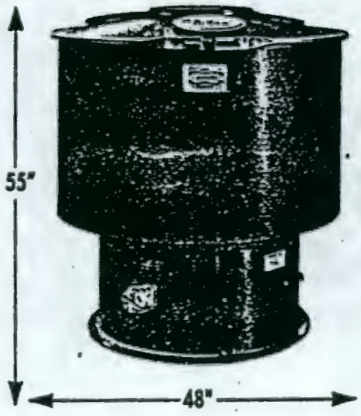
M18 Low Amplitude Grinding Mill
Maximum working capacity is 2.6 gallons. Standard base with 12 spring assemblies. Product discharge valve assembly. Metal cover assembly. Motion generator: 1/4 HP. Shipping weight: 200-250 lbs. Normal media load: 200 lbs. 1/2" sintered alumina rods.



M18/5 Multiple-Chamber Low Amplitude Grinding Mill
The M18/5 was designed for simultaneous test grinding, dispersion, and sampling of up to 5 different types of materials in small batches. Working capacity in each chamber is 1 pint. Metal cover assemblies are locked into place during grinding cycle. Motion generator: 1/4 HP. Shipping weight: 200-225 lbs.

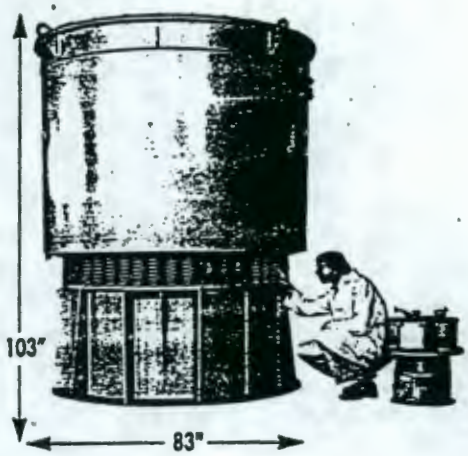


M45 Low Amplitude Grinding Mill
Maximum working capacity is 27 gallons. Standard base with 12 spring assemblies. Cover assembly with one charge port, and product discharge assembly with product discharge valve. Motion generator: 5 HP. Series grinding connection for all types available as an option. Shipping weight: 1,400-2,200 lbs. Normal media load: 2,100 lbs. 1/2" sintered alumina rods.



M60 Low Amplitude Grinding Mill
Maximum working capacity is 70 gallons. Standard base with 34 spring assemblies and a remote drive weight bearing assembly. Cover assembly with one charge port. Motion generator: 10 HP. Series grinding connection for all types available as an option. Shipping weight: 5,500-7,500 lbs. Normal media load: 5,600 lbs. 1/2" sintered alumina rods.

M80 Low Amplitude Grinding Mill
(Also shown M 18/5 Lab Model)
Maximum working capacity is 182 gallons. Unit features 46 heavy-duty springs. Heavy-duty bearings. Lube-Pak system. Water-cooled chambers available with stainless steel or cast bottom units. Bolted cover assembly with three charge ports. Media discharge port. Product discharge valve assembly. Series grinding inlet. Motion generator: 40 HP (optional 20 and 50 HP also available). Shipping weight: 11,000-16,000 lbs. Normal media load: 14,000 lbs. 1/2" sintered alumina rods.



Lining configurations available for low amplitude mills:
L — Replaceable abrasion-resistant elastomer lining.
S — Type 316 Stainless Steel grinding chamber. Water jacket available.
RC — Cast bottom with bolt-on inner and outer type 316SS walls to permit easy replacement as needed.
C — Ceramic lined chamber.
T — Ceramic lined with a solvent resistant fluoropolymer elastomer.

SWECO VIBRO-ENERGY GRINDING MILL LABORATORY TEST RESULTS

Figures 1 through 5 compare milling efficiency of a ball mill versus a Vibro-Energy Mill. Data was taken from laboratory tests using the best possible operating practice for the two pieces of equipment. Milling time in hours has been plotted against specific surface area which is a function of particle size. Media size and type, as well as solid to liquid ratio, were based on optimum conditions for each mill. Samples were removed from the mills at various grinding time intervals to determine the specific surface area.

Figure 6 shows typical particle size distribution curves of the ball mill versus the Vibro-Energy Mill. It should be noted that the milling time for the Vibro-Energy Mill was 8 hours compared to 24 hours for the ball mill. In general, the longer the milling time, the more narrow the size distribution. The plot which was made on semi-log paper shows that particles ground in a ball mill range from 0.5 to 40 microns, compared to 0.5 to 12 microns in the Vibro-Energy Mill.

Figure 7 is a plot of power consumption versus specific surface area for the ball mill and Vibro-Energy Mill. The ball mill requires approximately 7 1/2 times more energy than the Vibro-Energy Mill when reducing Zircon from a surface area of 30,000 to 35,000 cm ^{2}/gm.

Figure 8 is a plot of media wear comparing the ball mill and Vibro-Energy Mill when milling Zircon to a specific surface area of 35,000 cm ^{2}/gm. Media wear in lbs/lb. of product produced is approximately 7 times more for the ball mill than for the Vibro-Energy Mill in the surface area range of 35,000 cm ^{2}/gm.

$d = \frac{1}{\ldots} \cdot \frac{\ldots}{\ldots}$

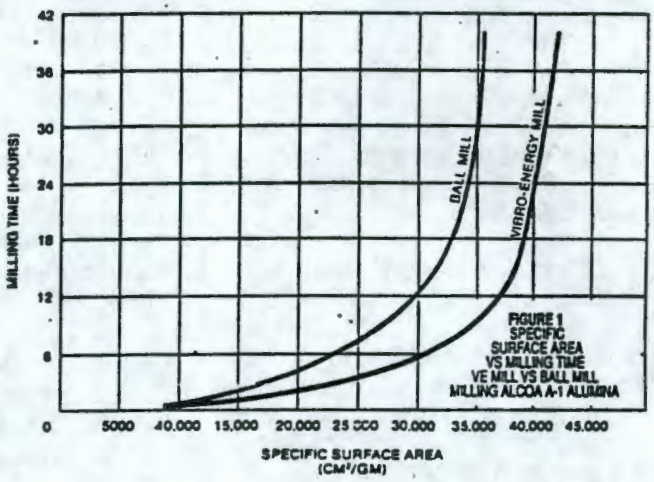


FIGURE 1
SPECIFIC SURFACE AREA VS MILLING TIME VE MILL VS BALL MILL MILLING ALCOA A-1 ALUMINA

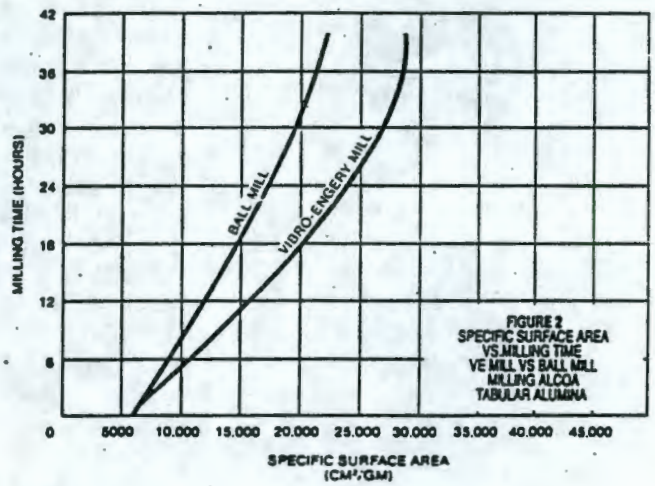


FIGURE 2
SPECIFIC SURFACE AREA VS MILLING TIME VE MILL VS BALL MILL MILLING ALCOA TABULAR ALUMINA

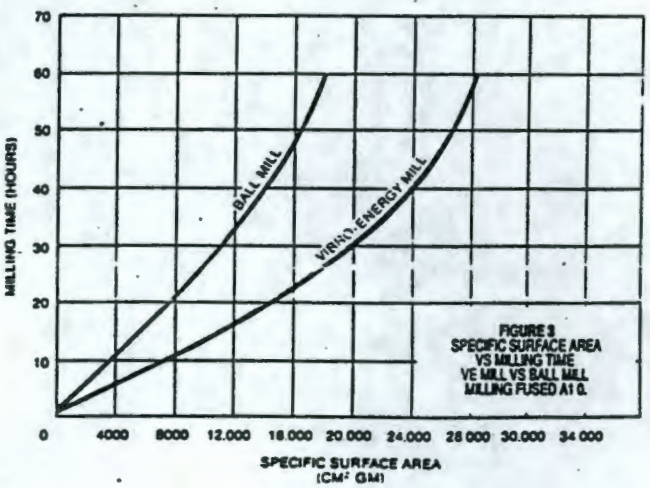


FIGURE 3
SPECIFIC SURFACE AREA VS MILLING TIME VE MILL VS BALL MILL MILLING FUSED Al 0.

Weight-Adjustment Effects on Screening Patterns

These diagrams show the screen patterns obtainable when you change the angle by which the lower motion-generator weight leads the upper one. Adding or removing weight plates amplifies or decreases horizontal or vertical amplitudes, thus affecting screening throughput rate and efficiency ratio.

(These patterns are those of an 18" diameter Separator and illustrate the principle. Other SWECO units have varying patterns, including the Parallel Feed Separator that has much higher settings. These are nominal for material in the range from 35-70 lb/cu ft; patterns will vary with other density.)

0° lead
Average material will be thrown straight

15° lead
Average material will begin to spiral

35° lead
Average material will give maximum screening pattern

90° lead
Oversize material does not discharge

SWECO Separator Features and Advantages

Widest Range of Materials Screened. Only SWECO Separators can handle such a broad range of materials...wet or dry, fine or coarse, heavy or light. Particles as fine as 400 mesh can be screened at high production rates.

Single or Multiple Separations. As many as four screen decks can be incorporated in one SWECO Separator, providing simultaneous separation into five fractions.

Greater Capacity and Cleaner, More Accurate Screening. In comparative tests, SWECO Separators have shown greater capacity per square foot of screening area than other types of screening devices. And the percentage of undersize discharged with oversize can be less with SWECO Separators than any other screening device.

Less Blinding. Vibro-Energy action holds most screen blinding to an acceptable minimum. However, certain materials have inherent blinding characteristics. For unusual situations, SWECO has developed accessories (page 30) to eliminate blinding.

Longer Screen Life. Each screen cloth is held in uniform tension by drawing it taut on tension rings. The drum-tight screening surface vibrates freely without whipping against rigid supports, greatly reducing screen wear and increasing screen life.

No Transmitted Vibration. No special flooring or foundation is needed. The unit may be placed (and easily moved) wherever it is needed. Many users mount their SWECO units on casters, on top of bins, on open grids, on wood, on upper floors, or on light structures not designed for rectangular vibratory screening equipment.

Less Space Required. For equivalent capacity, SWECO Separators require less working floor space than other screening systems. Compact SWECO units normally fit right into existing production lines.

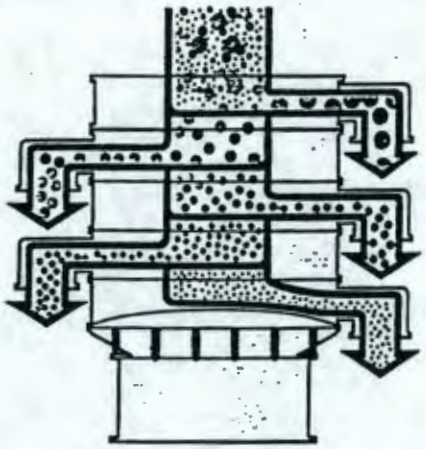
Economy–Long Life, Less Power, Low Maintenance. Simplicity of design with few moving parts assures long life with little maintenance. Because of efficient design, SWECO Separators require less horsepower than other units of similar capacity. Remarkably long screen life and the ease with which screens may be changed result in further economies.

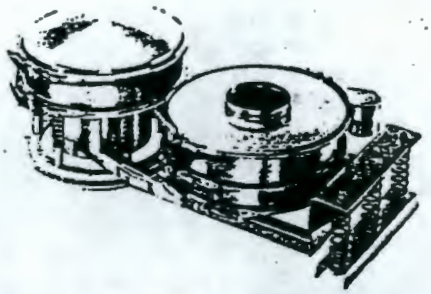
Functions of SWECO Vibro-Energy Separators

Alternate Designs Engineered for Special Applications

Sizing

Sizing or classifying is the segregation of solid particles into groups of comparable size. SWECO accurately separates up to five sizes continuously with a single Separator.

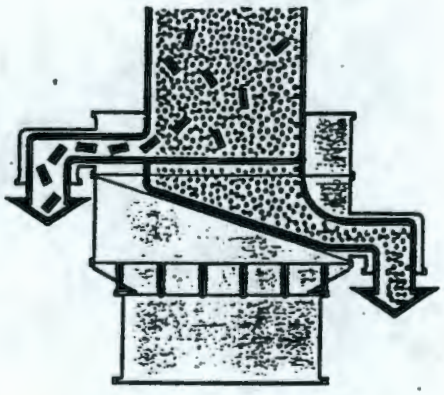


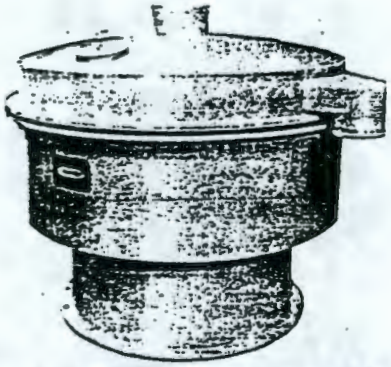


18 Inch Low-Profile Separator
LP18

Scalping

Scalping removes a small percentage of oversize particles in a high-throughput process. Standard SWECO Separators are highly effective scalpers. However, SWECO also provides special scalping units with high capacity discharge capabilities.

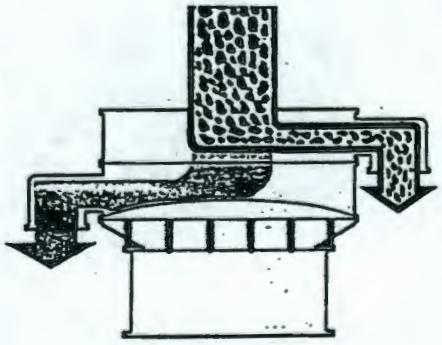


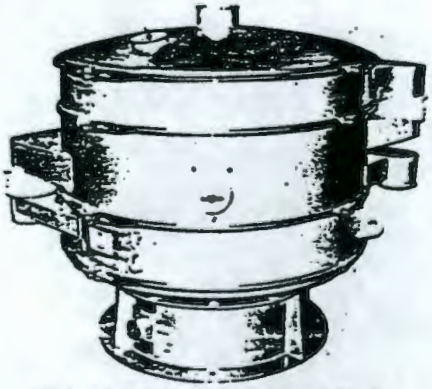


48, 60, & 72 Inch Vapor Tight Units
US48C88VT

Gravity Filtering

Gravity filtering, prefiltering, or dewatering removes solids from all types of liquids or slurries. SWECO Separators perform this function at throughputs as high as 1500 gpm.





48 & 60 Inch Series Feed Units
US60C8158

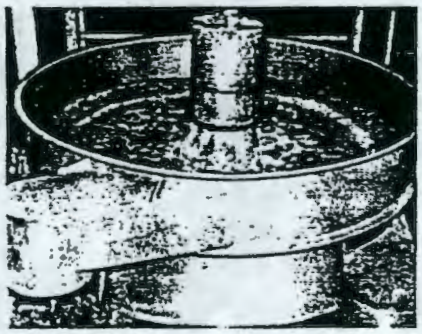
Industries Where SWECO Separators Are Used

Since 1949, SWECO has supplied its equipment to virtually every process industry. Today, more than 30,000 Separators are in use. SWECO Separators are contributing to increased production efficiency and product quality in many industries; a few are illustrated on the following pages. To get additional information, call us direct. Your problem may already have been solved.

Animal Feed

Poultry and animal feed producers are learning that SWECO Separators are ideal for maintaining product uniformity.

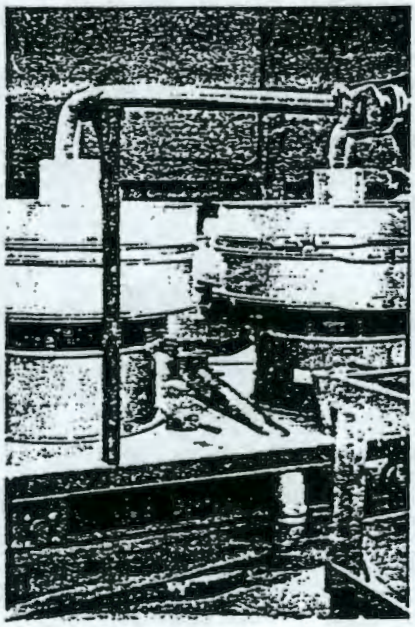
Wet spent grains from a brewing process are pressed, dried and sold as cattle feed. One company had a problem with too great a percentage of the grain being lost in the pressing and drying operation. The problem was solved by installing a 48" SWECO Separator equipped with a 60 mesh screen cloth (.0092" opening). Eighty gallons per minute of wet spent grain are handled by the Separator with 30 pounds per minute of spent grain (85% moisture) being recovered and sent to the dryer. The SWECO Separator has increased the output of feed grain significantly.



Ceramic

Manufacturers of ceramic products must remove fine impurities from ceramic slip in order to produce a high-quality product.

In the installation shown below, two SWECO 48" Separators have been installed on rails over 12 storage tanks to allow one unit to do the job of six stationary units. The slip is screened at a rate of 5,000 gallons per hour through 120 mesh screens. A manifold tank-loading system, with quick disconnect couplings, permits ready traverse from one pair of tanks to the next.



Chemical

Over 2,000 SWECO Separators are presently used in the chemical process industries to efficiently and economically perform all separator process functions.

Manufacturers of powdered detergents, for example, need to eliminate oversize granules, which detract from eye appeal of the product and retard the rate at which they will dissolve. Since the detergent is bone dry at time of scalping, dust and screen capacity were a problem with a rotating trommel sieve. Two 48" SWECO Separators with 4 mesh screens solved the capacity problem for a major producer by handling seven tons per hour, while holding oversize between .5 to 1%. The use of metal covers and flexible spout connectors also eliminated dust.

Industries Where SWECO Separators Are Used

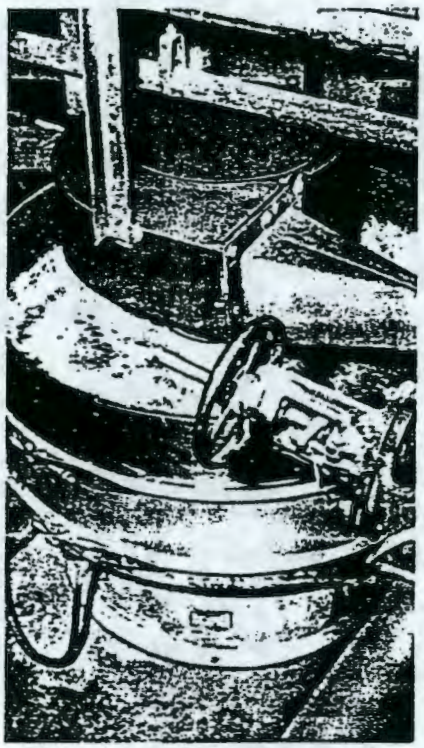
Food

Canners, cereal manufacturers, meat producers, and other food processors are saving money and improving product quality with SWECO Separators.

The production of a high-quality citrus juice requires a consistently low level of pulp content in the finished product, regardless of the type of fruit being processed. An international manufacturer of orange juice uses these two 48" SWECO Separators with 24 mesh screens to reduce the pulp content from 20% to 5%. SWECO's adjustable action does not damage juice cells. Each Separator handles up to five tons of juice per hour.

Industrial Laundries

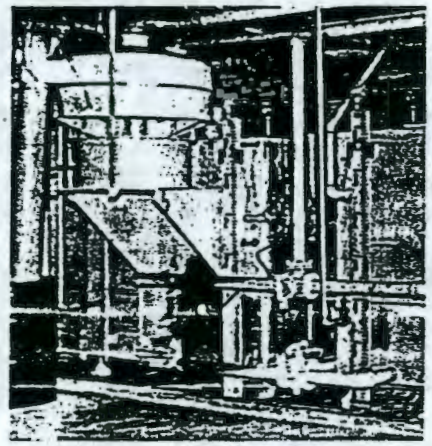
Accumulations of lint can create costly downtime and heavy sewer assessments for industrial laundries. In this Baltimore installation, a single 48" SWECO Separator, equipped with a 60 mesh market grade screen, delivers the lint to a 55-gal. drum and discharges screened wastewater to the sewer. Impressive savings in costs are being realized and complaints from city officials have been eliminated.



Bottling

SWECO units have proved ideal for recovering spent grains and for separating trash from caustic solutions used in the brewing industry.

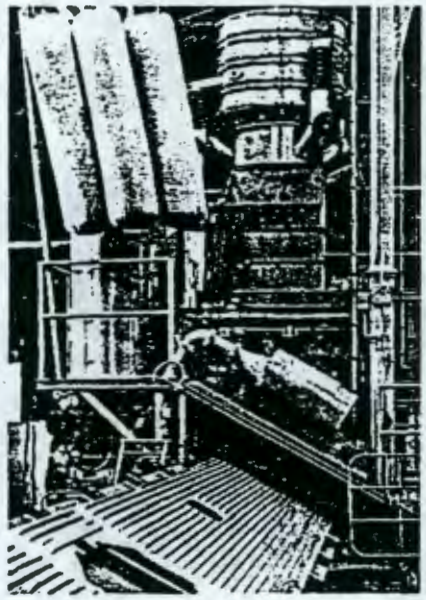
A major brewery concluded that if they could mechanically separate broken glass, labels and debris from a caustic solution used in bottle washing, they could (1) eliminate man-hours spent in manual handling of debris, and (2) regenerate and reuse the solution. Several methods were rejected before a 48" single deck SWECO Separator was installed. Equipped with a 60 mesh stainless screen (.0072 in. wire diameter and 30.5% open area), the unit is successfully processing 150 gallons per minute of caustic solution.



Metalworking

Recovering valuable steel shot and grit from sand, dust and tramp metal is an important service performed in the metalworking industry.

At one company, a 48" SWECO Separator classifies steel shot at 240 pounds per minute into three sizes (.023, .055 and .093 in. dia.). These steel shot sizes are used in the forming process for wing panels or skins for military and commercial jet aircraft. The Separator enables a changeover in the company's shot peening operation in just five minutes.



Petroleum

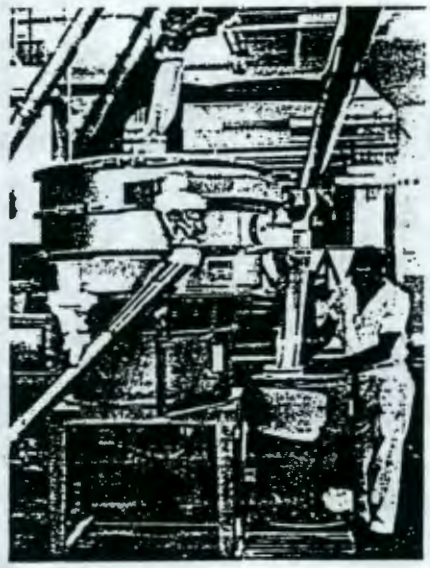
In several petroleum applications, the unique ability to place SWECO Separators on elevated structures has proved invaluable in sizing and reclaiming catalyst pellets.

At this installation, a SWECO Separator with a 6 mesh screen cloth removes fines from TCC grade catalyst pellets. Screen blinding, a problem with previous equipment, is now eliminated.

Pharmaceutical

Many types of granulated powders and pellets are accurately and uniformly processed with SWECO Separators.

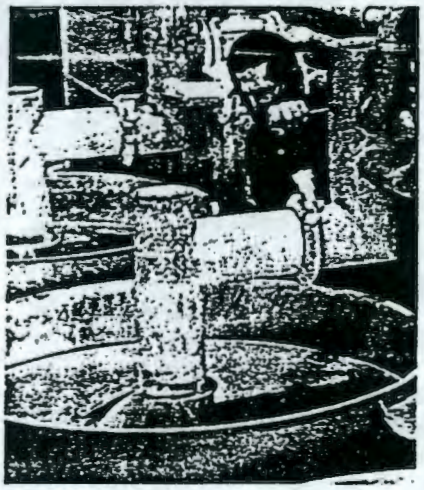
The screening of granular material for use in tablets and capsules poses blinding and dust control problems for pharmaceutical manufacturers. This double deck SWECO Separator includes a 24 mesh and an 84 mesh screen. The minus 24 mesh, plus 84 mesh product-fraction was produced in one-eighth the time of the previous sifter. The SWECO unit also eliminated the dust problem.



Pulp and Paper

SWECO applications in the paper industry include: screening adhesives, starch solutions, paper coatings, starch tub size; removing pulp and other contaminants from cleaning water and wastewater; scalping and sizing wood chips.

Shown here are two of the fifteen 48" SWECO Separators used by one of the world's largest paper mills. Using 50 to 200 mesh screens, the Separators filter up to 30 gpm per unit of uniform quality coating–enough to coat 2,100 miles of paper each day.



Sand and Gravel

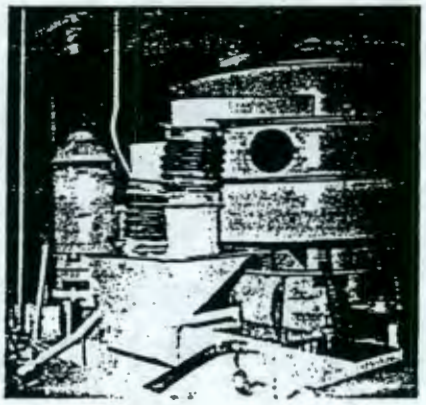
Producers of silica sand must furnish a wide range of closely controlled sizes of product to meet the diverse needs of their customers.

Commercial tolerances call for 85% of product within a specified size range. One silica sand producer installed a battery of six 48" SWECO Separators, including single, double and triple deck units. This facility has consistently produced a product of 97% accuracy. As a result, they have experienced a growing demand for their products.

Sugar and Syrup

A common problem in the sugar industry is the removal of dirt and bagacillo from sugar cane juice–a function that is often impossible with conventional screening devices.

A large producer of molasses, using rectangular screens, encountered shutdowns due to frequent blinding and screen breakage. The company solved their problem by installing a 2 deck 48" SWECO Separator. They are now screening 175 to 200 gallons of melt per minute, continuously, through 16 and 94 mesh cloth with operating cycles of 3-4 weeks, seven days per week, 24 hours per day, with no interruptions of the production process due to the screening operation.



Applications and developmental testing are conducted in our fully staffed Technology Center.

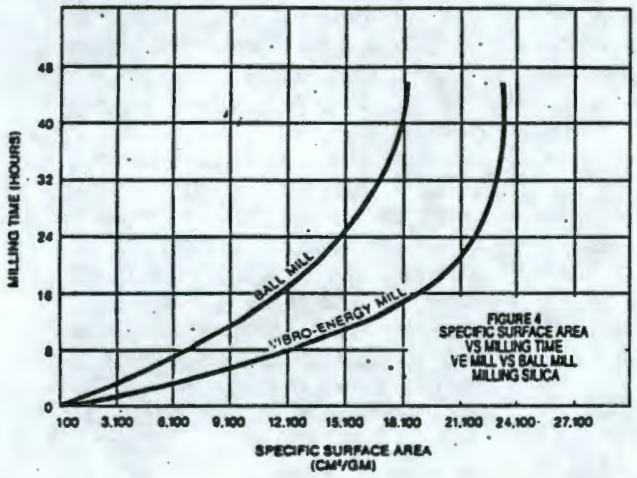


FIGURE 4
SPECIFIC SURFACE AREA
VS MILLING TIME
VE MILL VS BALL MILL
MILLING SILICA

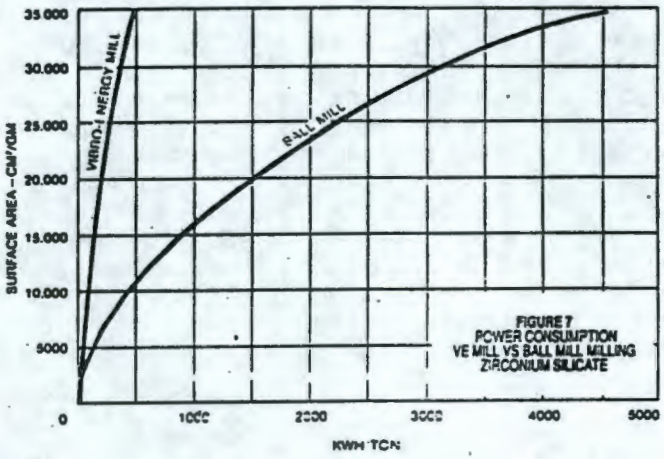


FIGURE 7
POWER CONSUMPTION
VE MILL VS BALL MILL MILLING
ZIRCONIUM SILICATE

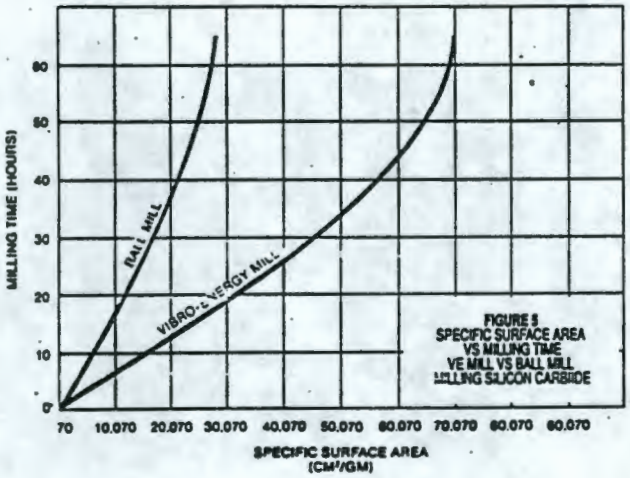


FIGURE 5
SPECIFIC SURFACE AREA
VS MILLING TIME
VE MILL VS BALL MILL
MILLING SILICON CARBIDE

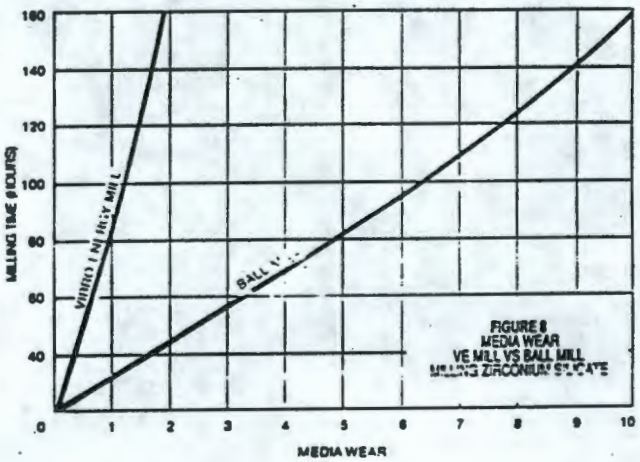


FIGURE 6
MEDIA WEAR
VE MILL VS BALL MILL
MILLING ZIRCONIUM SILICATE

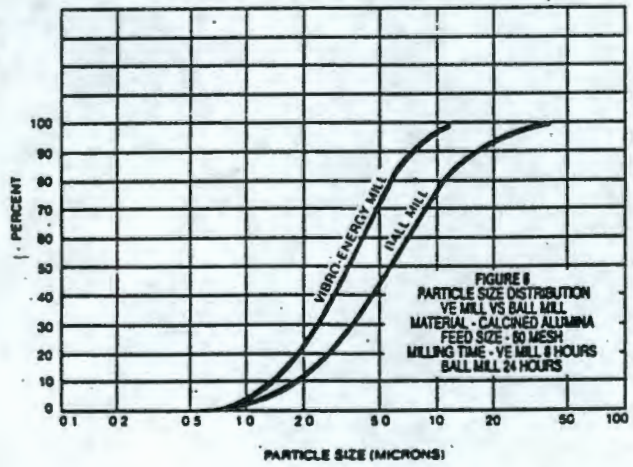
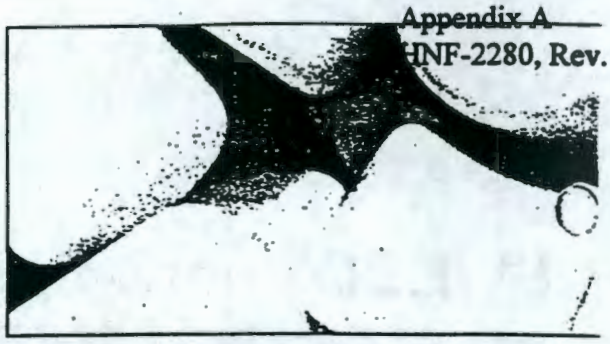


FIGURE 8
PARTICLE SIZE DISTRIBUTION
VE MILL VS BALL MILL
MATERIAL - CALCINED ALUMINA
FEED SIZE - 60 MESH
MILLING TIME - VE MILL 8 HOURS
BALL MILL 24 HOURS

SWECO GRINDING MEDIA



SWECO offers a complete line of grinding media, developed by evaluating results from extensive testing in many industrial applications.

To achieve narrow particle size distribution during wet grinding, cylindrical media is usually recommended, due to the resulting combination of point, line, and face contact. However, in other applications (especially those involving dry grinding or the use of larger feed sizes) spherical media is often used. The point contact developed by spherical shapes will transmit the higher impact forces often required in these applications.

For information on special applications or for recommendations on the best media for your particular grinding requirements, contact your local SWECO Representative.

A full line of SWECO Grinding Media

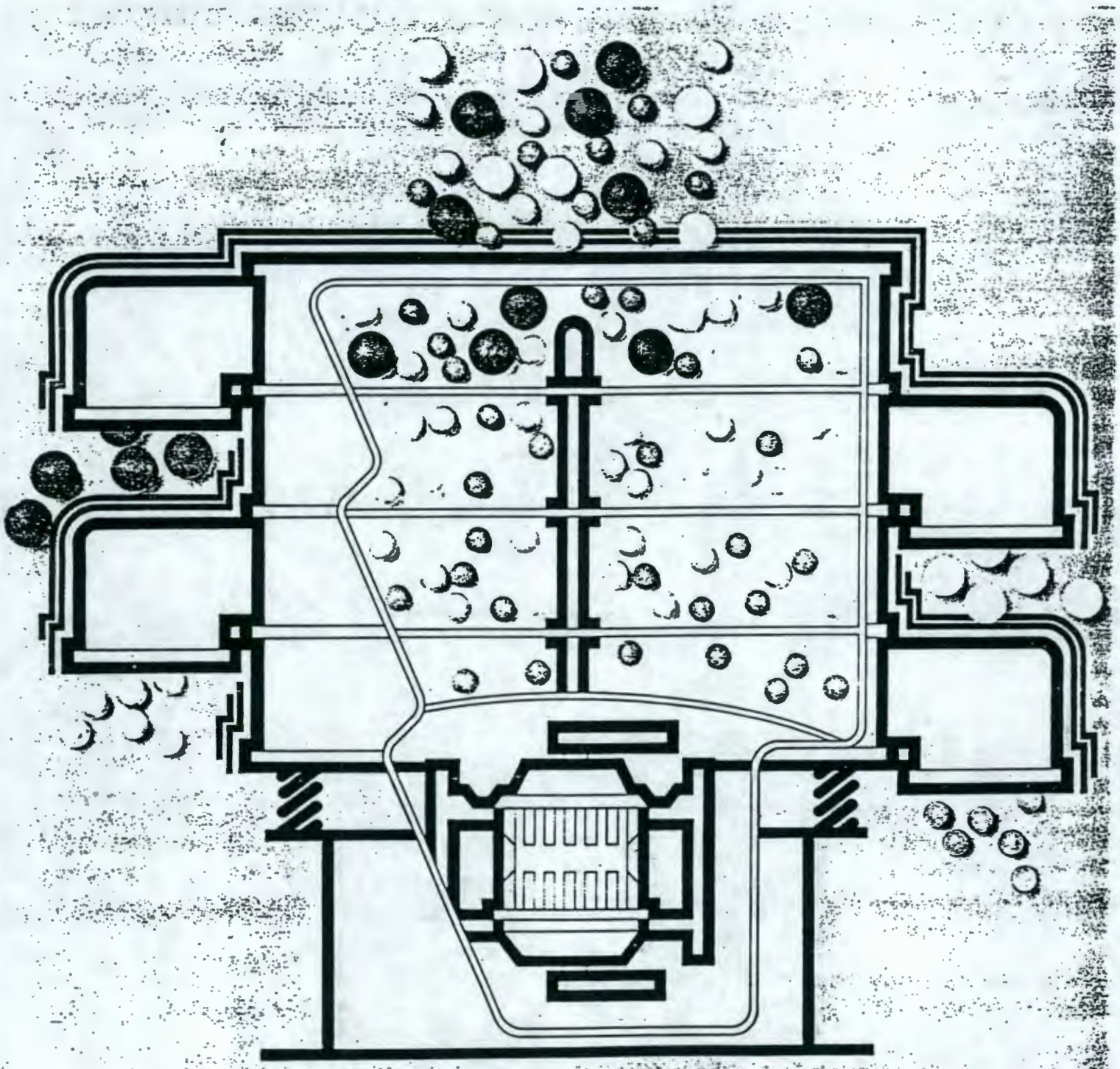
Grinding Media	Sizes Available	Specific Gravity
High-density alumina cylinders	¼", ½", ¾", 1¼"	3.5
High-density alumina balls	⅜", ½", ¾", 1", 1¼", 1½", 2"	3.6
Zirconium silicate (Zircon) cylinders	½", ¾"	3.7
Zirconia cylinders	⅜", ½", ¾"	5.5
Case-hardened steel cylinders	½"	7.8
Carburized steel balls	Range from 3/32" to 11/16"	7.8

Typical maximum media loads (in pounds) for various SWECO Grinding and Dispersion Mills

MILL TYPE (MODEL)	ALUMINA AL_2O_3 CYL.	ALUMINA AL_2O_3 BALLS	ZIRCON $ZrSiO_4$ CYL.	ZIRCONIA ZrO_2 CYL. (RADIUS END)	STEEL CYL.	STEEL BALLS
M18	200	185	200	250	250	250
M45	2100	2000	2100	2100	2100	2100
M60	5600	5200	5600	5600	5600	5600
M80-40	14000	13000	14000	18000	18000	18000
DM-1	80	70	80	80	80	80
DM-3	300	275	300	300	300	300
DM-10	1000	900	900	1600	1600	1600
DM-20	2000	1800	2200	2200	2200	2200
DM-70	7000	6500	10000	10000	10000	10000

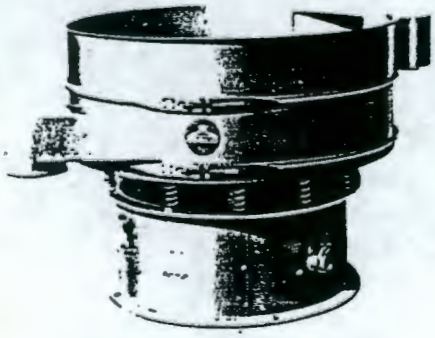
All specifications are subject to change without notice.

SWECO® Vibro-Energy® Separators

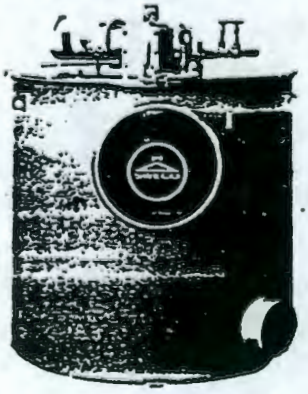


Your First Choice for Ultra-Efficient Screening, Separating and Grinding Equipment

Separators. Separate solids from liquids or segregate dry materials into various particle sizes. Particles as fine as 400 mesh (37 microns) can be screened. As many as 4 screen decks can be incorporated in one SWECO Separator for simultaneous separation into five fractions. No special flooring or foundation is needed and less working floor space is required. Simple and efficient design requires less horsepower. Other features include long screen life and ease with which screens may be changed.

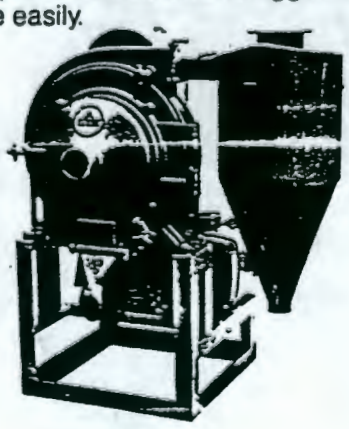


Centrifugal Screen Concentrators. Provides high flow rate, fine mesh centrifugal screening to remove all particles larger than screen mesh opening with no dependence on differences in specific gravity. Ideal for effluent and water recycle streams for large plants. Units available that remove suspended solids down to 500 mesh (25 microns).

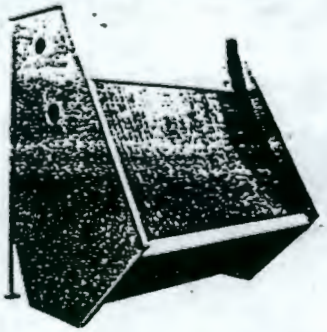


Grinding Mills. Most versatile line of mills available today for fast, low-cost particle size reduction to sub-micron range. Vibro-Energy® grinding action achieves higher output per input horsepower; precise control of size and size distribution. Product contamination from media and lining wear is virtually eliminated. Maintenance costs are low because of few moving parts and replaceable linings made of abrasion-resistant metal, ceramic or elastomers.

Turbo-Screen Classifiers. Provides continuous, precise screening of dry materials, especially in the finer particle sizes. Uses screen sizes from 20-400 mesh for efficient separation of particles ranging from 850-37 microns. Handles the most difficult materials, including electrostatic materials and particles that tend to agglomerate easily.

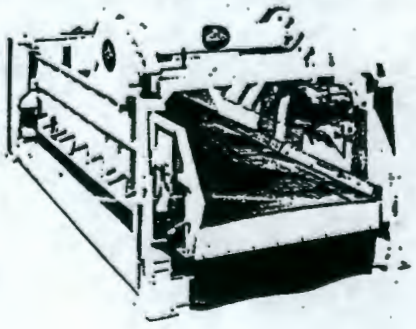


Sta-Sieve Stationary Screening Device. Provides quick and efficient separation of solids from liquid. Ideally suited for processors that use large quantities of water. Advantages of this low-cost unit include high-flow rate, long screen life and no moving parts. Can be operated independently or as a system component in conjunction with SWECO Separators or Centrifugal Screen Concentrators.



Full-Flow Separators. New technology adapts ultra-fine screen mesh for use in rectangular high-capacity separators (36 ft^2), yielding benefits previously found only on small circular screens.

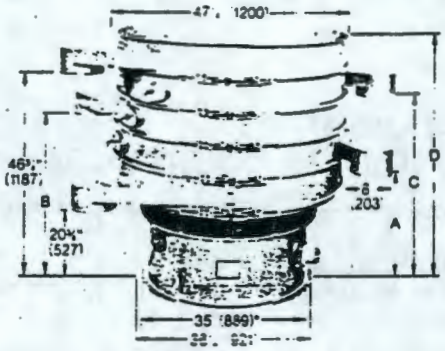
Fine-mesh screen panels can be installed in five minutes without tools on some models. Once in place, an O-ring system creates a positive seal against bypass.



48 Inch (1219 mm) Diameter Units

Motion-Generator Data: SWECO-built; totally enclosed; 2½ hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm. One- and two-deck units also available with 1800 rpm drive.

Dimensional Data is typical. To the heights shown, for a cover add 8¼ inches (210 mm); ball tray add 2½ inches (64 mm).



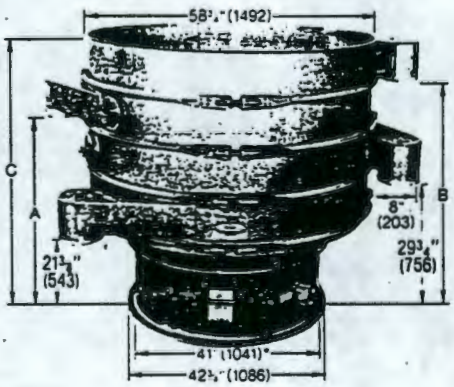
US48C66666

Model	No. Decks	A	B	C	D	Net Weight
		Inches (Millimeters)				Lbs. (Kg.)
US48C66	1	27¼" (692)	—	—	35" (889)	659 lbs. (299)
US48C666	2	27¼" (692)	33¾" (857)	—	41¼" (1048)	758 lbs. (344)
US48C6666	3	27¼" (692)	33¾" (857)	40¼" (1022)	48" (1219)	857 lbs. (389)
US48C66666	4	27¼" (692)	33¾" (857)	40¼" (1022)	54¾" (1391)	971 lbs. (440)
US48C88	1	29" (737)	—	—	37" (940)	665 lbs. (302)
US48C888	2	29" (737)	36" (914)	—	43½" (1105)	773 lbs. (351)
US48C8888	3	29" (737)	36" (914)	42¼" (1073)	49¾" (1264)	872 lbs. (396)
US48C888	2	29¼" (743)	37¾" (959)	—	45¼" (1149)	779 lbs. (353)
US48C8888	3	29¼" (743)	38" (965)	46" (1168)	53½" (1358)	888 lbs. (403)
US48C88	1	29¼" (743)	—	—	39" (991)	671 lbs. (304)
US48C888	2	29¼" (743)	38" (965)	—	47½" (1206)	781 lbs. (354)

60 Inch (1524 mm) Diameter Units

Motion-Generator Data: SWECO-built; totally enclosed; 2½ hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm. One- and two-deck units also available with 1800 rpm drive.

Dimensional Data is typical. To the heights shown, for a cover add 10 inches (254 mm); ball tray add 2½ inches (64 mm).



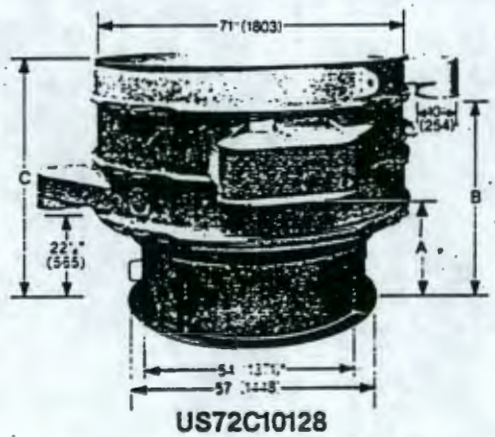
US60C8888

Model	No. Decks	A	B	C	Net Weight
		Inches (Millimeters)			Lbs. (Kg.)
US60C88	1	—	—	39⅛" (933)	690 lbs. (313)
US60C888	2	38¼" (972)	—	47⅝" (1210)	833 lbs. (378)
US60C8888	3	38¼" (972)	46⅝" (1184)	56" (1422)	975 lbs. (442)
US60C8108	2	40¼" (1022)	—	49⅝" (1260)	840 lbs. (381)
US60C81088	3	40¼" (1022)	48⅝" (1235)	58" (1473)	983 lbs. (446)
US60C810108	3	40¼" (1022)	50⅝" (1286)	60" (1524)	991 lbs. (450)

72 Inch (1829 mm) Diameter Units

Motion-Generator Data: SWECO-built; totally enclosed; 5 hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm.

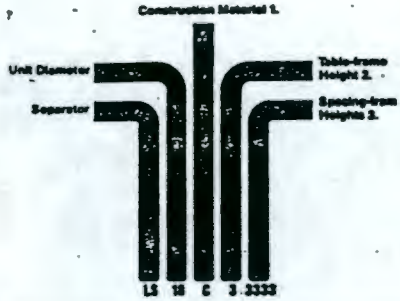
Dimensional Data is typical. To the heights shown, for a cover add 12⅜ inches (314 mm).



US72C10128

Model	No. Decks	A	B	C	Net Weight
		Inches (Millimeters)			Lbs. (Kg.)
US72C108	1	—	32⅞" (835)	42½" (1070)	1,800 lbs. (816)
US72C10128	2	32⅞" (835)	45¼" (1156)	54¾" (1387)	2,100 lbs. (953)

SWECO, Inc., has patents granted and pending in the United States and other countries.



Key to Model Alphanumeric Code

1. For construction material, C designates carbon steel, S stainless steel.

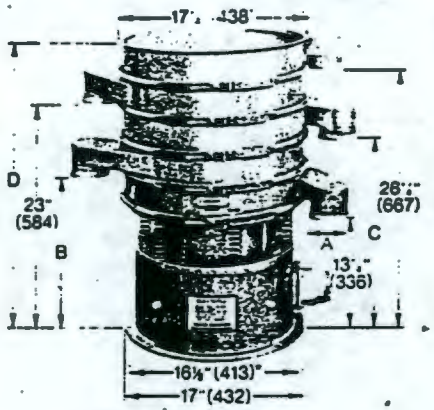
2. Table-frame heights are 3, 4, 5, 6, 8, 10, 15, 16, 18 and 24 inches (76, 102, 127, 152, 203, 254, 406, 457 and 610 mm). To avoid double digit confusion, remember there are no 1-inch (25 mm) tabl spacing-frames. Thus, in LS48C156, there is one 15-inch (381 mm) table-frame and one 6-inch (152 r spacing-frame.

3. Spacing-frame heights are 3, 4, 5, 6, 8, 10, 15, and 18 inches (76, 102, 127, 152, 203, 254, and 457 mm). The number of spacing-frames is counted to the right from the table-frame. Thu LS60C810108, the digit 8 immediately following construction material is the table-frame. There are th spacing-frames of 10-, 10-, and 8-inch (254, 254, and 203 mm) heights, respectively.

18 Inch (457 mm) Diameter Units

Motion-Generator Data: Totally enclosed, ¼ hp; 230, 460 or 575 v; 60 Hz; 3-phase, 1200 rpm (¼ hp, 115 v, single-phase motion-generator available).

Dimensional Data is typical. To the heights shown, for a cover add 5½ inches (140 mm); ball tray, add 2¼ inches (57 mm).



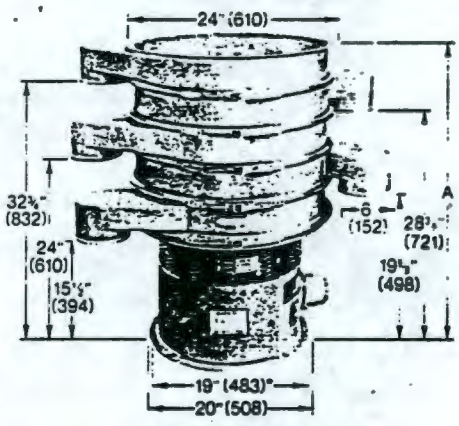
LS18S33333

Model	No. Decks	A	B	C	D	N We
		Inches (Millimeters)				Lbs.
LS18S33	1	3¼" (83)	16½" (419)	—	20½" (521)	13((5
LS18S333	2	3¼" (83)	16½" (419)	19¾" (502)	23¾" (603)	13. ((
LS18S3333	3	3¼" (83)	16½" (419)	19¾" (502)	27" (686)	15' ((
LS18S33333	4	3¼" (83)	16½" (419)	19¾" (502)	29¾" (756)	16. (
LS18S35	1	3¼" (83)	16½" (419)	—	22½" (571)	13: ((
LS18S53	1	4" (102)	18½" (470)	—	22½" (571)	13: ((
LS18S533	2	4" (102)	18½" (470)	21¾" (552)	25¾" (654)	14' ((
LS18S55	1	4" (102)	18½" (470)	—	24½" (622)	13(((
LS18S553	2	4" (102)	18½" (470)	23¾" (603)	27¾" (705)	14- ((

24 Inch (610 mm) Diameter Units

Motion-Generator Data: Totally enclosed; ½ hp, 230, 460 or 575 v; 60 Hz; 3-phase; 1200 rpm (½ hp, 115 v, single-phase motion-generator available).

Dimensional Data is typical. To the heights shown, for a cover add 4⅜ inches (111 mm); ball tray, add 2⅜ inches (60 mm).



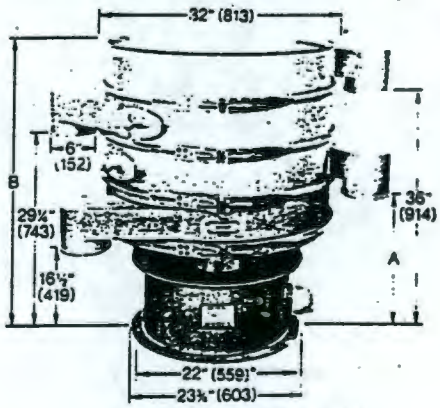
LS24C44444

Model	No. Decks	A	N We
		Inches (Millimeters)	Lbs.
LS24C44	1	25¼" (641)	181 (8
LS24C444	2	29⅝" (752)	211 (9
LS24C4444	3	34" (864)	24((1
LS24C44444	4	38⅜" (975)	27((1.

30 Inch (762 mm) Diameter Units

Motion-Generator Data: Totally enclosed; ½ hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm.

Dimensional Data is typical. To the heights shown, for a cover add 5⅜ inches (137 mm); ball tray, add 2½ inches (64 mm).



LS30C6666

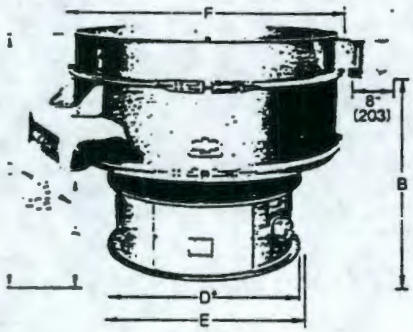
Model	No. Decks	A	B	N We
		Inches (Millimeters)		Lbs
LS30C66*	1	23" (584)	30½" (775)	33 (:
LS30C666*	2	23" (584)	37" (940)	40: (1
LS30C6666*	3	23" (584)	43½" (1105)	46 (2
LS30C66*	1	25" (635)	32½" (825)	35: (1

*Also available with 4" (102) spacing-frames

48 & 60 Inch (1219 mm & 1524 mm) Scalper Units

Motion-Generator Data: SWECO-built; totally enclosed; 2½ hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm.

Dimensional Data is typical. To the heights shown, for a 48 inch (1219 mm) unit cover add 8¼ inches (210 mm), and a ball tray, 2½ inches (64 mm). For a 60 inch (1524 mm) unit cover, add 10 inches (254 mm) and a ball tray, 2½ inches (64 mm).



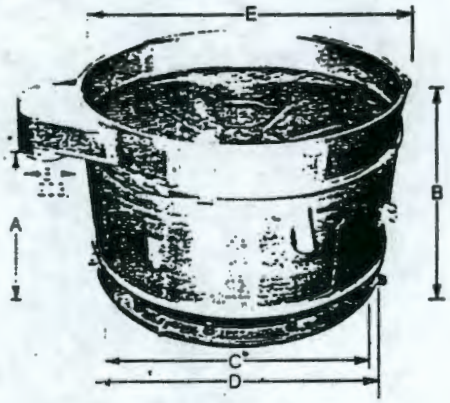
US60C156

Model	No. Decks	A	B	C	D	E	F	Net Weight
		Inches (Millimeters)						Lbs. (Kg.)
US48C156	1	22¾" (578)	36½" (927)	44¼" (1124)	35" (889)	36¼" (921)	47¼" (1200)	730 lbs. (331)
US60C156	1	23" (584)	36¾" (933)	44½" (1121)	41" (1041)	42¾" (1086)	58¾" (1492)	1,075 lbs. (488)

48, 60 & 72 Inch (1219 mm, 1524 mm & 1829 mm) Flo-Thru Units

Motion-Generator Data: SWECO-built; totally enclosed; 2½ hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm.

Dimensional Data is typical. Undersize material exits out bottom of unit. Bottom duct size variable from 16"-40" diameter.



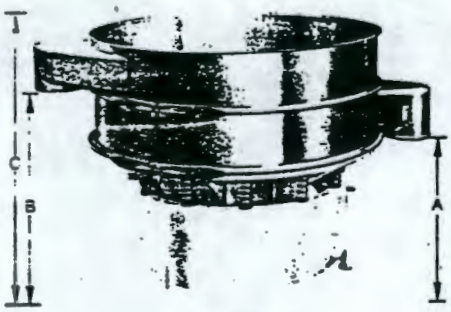
R60S248 FT

Model	No. Decks	A	B	C	D	E	Net Weight
		Inches (Millimeters)					Lbs. (Kg.)
R48C248 FT	1	31¼" (793)	40⅝" (1032)	43" (1092)	47" (1194)	47¼" (1200)	800 lbs. (363)
R60C248 FT	1	31¼" (793)	40⅝" (1032)	54½" (1384)	58" (1473)	58¾" (1492)	900 lbs. (408)
R72C268 FT	1	33½" (851)	42⅞" (1089)	54½" (1384)	58" (1473)	71" (1803)	1000 lbs. (454)

30, 48, 60 & 72 Inch (762 mm, 1219 mm, 1524 mm & 1829 mm) Sanitary Separator Units

Motion-Generator Data: SWECO-built; totally enclosed; 2½ or 5hp; 230/460 or 575 v; 60 Hz; 3-phase; 1200 rpm.

Dimensional Data is typical. Multi-deck machines are also available.



SS48S88

Model	No. Decks	A	B	C	Net Weight
		Inches (Millimeters)			Lbs. (Kg.)
SS30S66	1	18½ (470)	25 (635)	32⅜ (822)	339 (154)
SS48S88	1	21⅜ (543)	29⅞ (759)	39¼ (997)	671 (304)
SS60S88	1	22½ (572)	31 (787)	40⅜ (1026)	690 (313)
SS72S108	1	Consult SWECO			

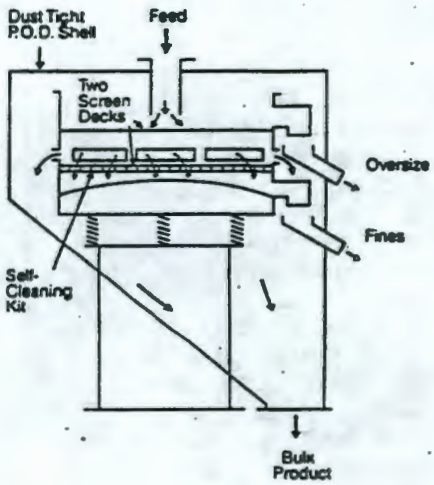
*Mounting hole bolt circle.

Other electrical and/or spacing frame specifications available on special order.

NEW PRODUCTS

48, 60 & 72 Inch P.O.D. Units (Peripheral Oversize Discharge)

The SWECO P.O.D. (Peripheral Oversize Discharge) Separator is a new product developed by SWECO for scalping and dedusting applications where high-volume capacity plus effective removal of fines and dust are required.



Specifications of Standard Models

Model	Screen Diameter	Motor	Height (Inches)	Net Weight (Pounds)	Maximum Production Rates
PD 48	48"	2.5 hp	112"	2800	.4 cu. ft./sec.
PD 60	60"	2.5 hp	120"	3400	.65 cu. ft./sec.
PD 72	72"	5 hp	126"	4000	1 cu. ft./sec.

All specifications are subject to change without notice.

18, 24, 30, 48, 60 & 72 Inch Accu-Feed Systems

A significant advance in dry materials processing.

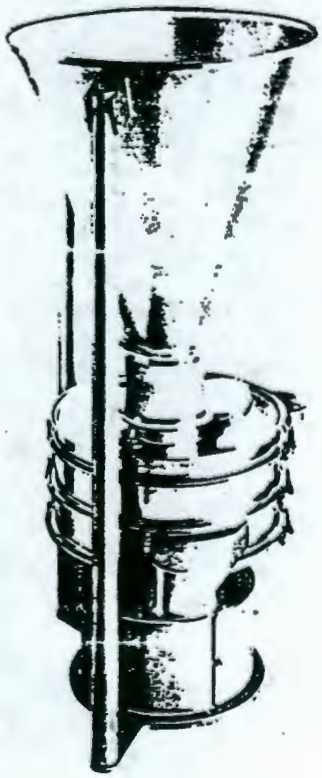
SWECO's new Accu-Feed System combines the three functions of storage, feeding and screening of dry materials into one complete unit. The result is a substantial increase in productivity and significant savings in capital, space and energy.

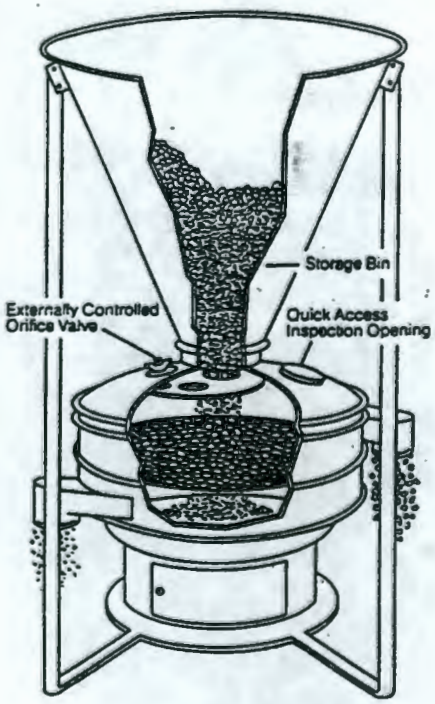
At the core of every Accu-Feed System is the world's best-selling separator—SWECO's Vibro-Energy® Separator, able to size your product into two to five fractions down to 325 mesh.

With its conical storage bin and adjustable feed controller, the Accu-Feed eliminates the need for stand alone feed hoppers, hopper evaculators and/or feeders, and screening separators.

Mass-flow product discharge from the bin into the Separator is enhanced by coupling the unique Vibro-Energy motion into the stored product. The feed rate (bin-to-separator) can be controlled by rotating a simple orifice valve.

Unique, externally controlled feed orifice valve permits flow adjustments without emptying the bin.





Why Buy From SWECO?

With the purchase of a SWECO Separator, you are selecting a product backed by 36 years of manufacturing experience and product innovation. As an owner of a SWECO Separator, your decision to buy the best in screening equipment brings with it these added services.

Availability of your local SWECO District Engineer for as long as you own a SWECO Separator.

SWECO's Application Engineering Staff, library, and test facilities providing sound technical backup.

SWECO Service Centers around the world providing parts and new screen service.

SWECO District Engineers.

SWECO District Engineers help select and orient the unit for installation.

Your Separator start-up is supervised, adjusted, and checked by the most experienced personnel in the industry, operating from 106 worldwide offices. These District Engineers have installed and successfully placed into operation more than 30,000 units for more than 2,000 applications.

SWECO Parts and Screen Centers.

Screens. Only SWECO makes the Supertaut™ Screen, increasing the productivity and quality of your process. Wherever you are located, SWECO can supply replacement screens quickly and efficiently. We back up our claims with a satisfaction guarantee.

Parts. SWECO stocks a complete line of standard Separator replacement parts. When you purchase a SWECO Separator, you are assured of quick replacement parts service that helps you get back into operation fast. The manual delivered with your new Separator helps you identify proper part numbers for reorder, as well as assisting you in installation, operation and maintenance.

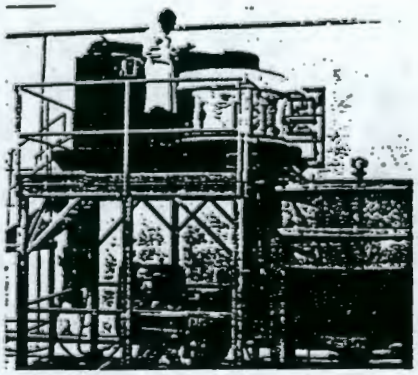
Motion-Generators. To maintain the highest possible quality standards, SWECO has its own 2½hp (and larger) motion-generators. Our design uses large double-row spherical roller bearings, top and bottom. They also have enlarged windings that are laced and double-dipped for longer life. With every new unit, SWECO provides a grease cartridge loaded with specially formulated lubrication at no cost to you.

Authorized motor repair stations provide high quality and timely repairs on SWECO motion-generators. When quick replacement is called for, SWECO will ship a new motion-generator from stock, with a full one-year warranty.

SWECO Application Engineering.

Staffed by experienced engineers, SWECO's Application Engineering Department has performance data from thousands of installations as well as data on many controlled tests at our solid and hydraulic test stands.

Small-scale field tests are not always possible. In these cases, the Application Engineering Department can perform production-scale solid and hydraulic tests at the Florence, Kentucky Research and Development Facility. These tests enable SWECO's Application Engineering Department to accurately specify the correct machine or system to solve your screening problem.

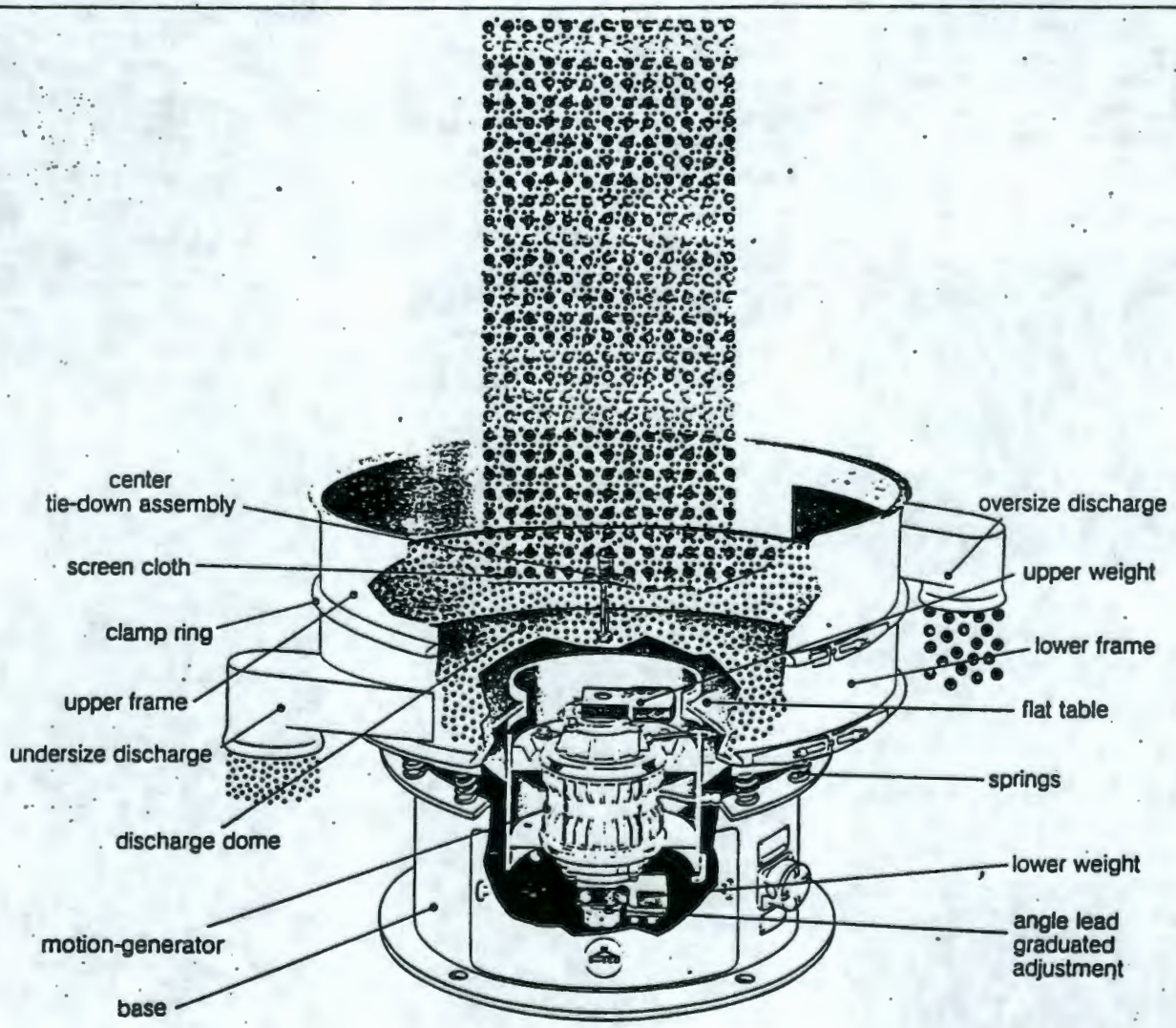


SWECO System Engineering.

Your problem may call for a custom-designed system including several components, such as a hydrocyclone/separator system or a grinding mill/separator system. SWECO Engineering has years of experience in this field.

How SWECO® Vibro-Energy® Separators Work

Basically, the SWECO Separator is a screening device that vibrates about its center of mass. Vibration is accomplished by eccentric weights on the upper and lower ends of the motion-generator shaft. Rotation of the top weight creates vibration in the horizontal plane, which causes material to move across the screen cloth to the periphery. The lower weight acts to tilt the machine, causing vibration in the vertical and tangential planes. The angle of lead given the lower weight with relation to the upper weight provides variable control of the spiral screening pattern. Speed and spiral pattern of material travel over the screen cloth can be set by the operator for maximum throughput and screening efficiency of any screenable product...wet or dry... heavy or light...coarse or fine... hot or cold.



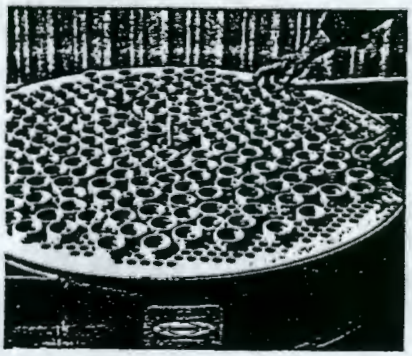
CUTAWAY...SWECO VIBRO-ENERGY SEPARATOR

Accessories

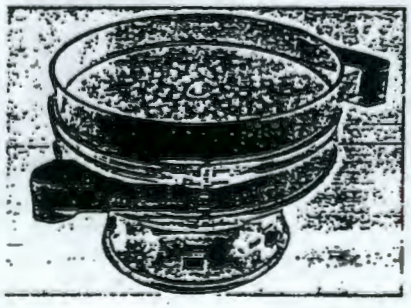
Your SWECO District Engineer will consult with you to determine the accessories best suited to your requirements.

Self-Cleaning Kit. SWECO's patented Self-Cleaning Kit prevents screen blinding and stapling. The action of the Separator causes sharp edged sliding cylinders to scrape the underside of the screen, cutting off dangling fibrous material as well as freeing near-size material lodged in the openings.

By reducing blinding, the Self-cleaning Kit improves dry sizing and liquid/solid separation.

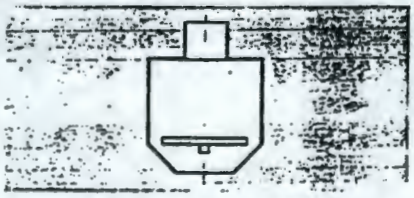


Ball Trays. For those desiring a conventional rubber ball anti-blinding arrangement, SWECO has available a Ball Tray. A coarse screen is mounted two inches below the sizing screen. Elastomer balls are placed on this coarse screen, and the unit's vibrating action bounces the balls against the underside of the screen cloth, dislodging particles.

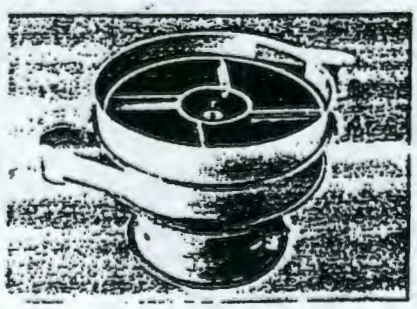


Supertaut Screens. Now users of any circular separator can obtain the highest quality screens available in the industry at a significantly reduced cost. There is also the added benefit of immediate shipment of these new screens from stock in strategically located centers. Available in 18", 24", 30", 48" and 60" diameter sizes.

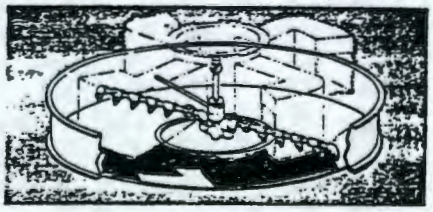
Liquid Feeders. Often called velocity reducers, SWECO supplies a stainless steel feeder in six pipe sizes (2" to 8") for flows ranging from 0-800 gpm.



Rotating Brushes. This equipment is used to remove oversize materials which have a tendency to staple over or entrap themselves in the screen. It has been successfully used in many wet or dry applications. No external drive mechanism is required to rotate the brushes. The 3-dimensional Vibro-Energy motion of the Separator forces the brushes to move in a preset direction.

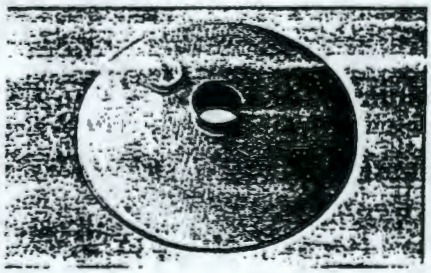


Rotating Spray. A Rotating Spray system is available as an accessory for screening applications in packing plants. The SWECO Rotating Spray consists of a revolving ball joint connector to which is attached two tubular arms having multiple spray nozzles. Hot water or steam used to remove the grease is fed through a stationary connection in the ball joint. The nozzles on

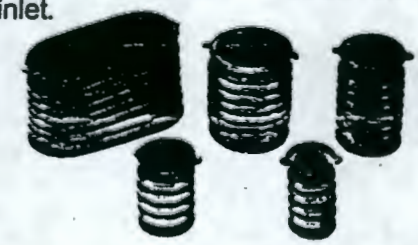


the tubular arms can be adjusted to spray at various angles. As the hot water is sprayed from the nozzles, the arms revolve and clean the entire screen surface. A non-rotating spray assembly is also available.

Covers. Dust and watertight metal, plastic or fabric covers are available for all size units.



Spout Connectors. Spout connectors of black or white neoprene, Viton® or silicone are available for all size SWECO Separator discharge spouts and cover feed inlet.



All specifications are subject to change without notice.

APPLICATIONS

In countless industries, SWECO Mills are providing the particle size reduction and distribution needed to fulfill specific application requirements. And in many cases, they have created opportunities for the development of products not even possible with competitive grinding methods.

Ceramics. A closely-controlled particle size distribution is extremely valuable in the production of body slips and glazes. Grinding time cycles are also reduced.

Pharmaceuticals and Cosmetics. Production of a uniform fine particle size is important in the grinding and dispersing of dermatological grinding and dispersion of emulsions in suspension.

Food. The grinding of key ingredients into small particle sizes produces more surface area and consequently more taste strength per unit. SWECO Mills enable the food industry to produce small particle sizes with minimal contamination and low product cost.

Agricultural Chemicals. In the production of pesticides, herbicides and fungicides, SWECO Mills help create superior flowables with uniform solids-to-liquid ratios. Products have a longer shelf life without settling-out, and spray jet clogging is reduced. In addition, the increased total surface area of the finer particles enhances the effectiveness of the materials. This permits smaller amounts of materials to be used in achieving the desired results.

Enameled Ware. The Vibro-Energy Mill is especially suitable for grinding porcelain enamel powder. Advantages include the ability to produce a product that will give maximum opacity and smoothness without producing excessive fines. Elimination of oversize particles and uniformity of distribution contribute to higher quality in the end product.

Organic Pigments. The Vibro-Energy Mill meets the requirements for achieving the full color strength important in grinding and dispersing of organic pigments. Contamination is controlled, and heat rise is reduced during the grinding of colors.

Inorganic Pigments. In the production of inorganic pigments for use in ceramics, paints, plastics, paper coatings, inks, leather finishes, floor and wall coverings, rubber, etc., narrow particle size distribution is highly desirable. Materials such as titanium dioxide, zirconium silicate, calcium carbonate and kaolin are being milled in Vibro-Energy equipment to very critical limits to create particles with maximum light scattering power and with a minimum of oversize and undersize particles.

Abrasives. In the abrasives industry where media wear is a problem, the use of Vibro-Energy Mills provide extended media life and subsequent savings. The ability to grind particles under 10 microns is of particular importance in the development of new artificial abrasives.

Special Applications. SWECO Mills are also well-suited to processing a wide variety of other materials including: powdered metals, tungsten carbides, rubber molding compounds, catalyst carriers and iron oxide for magnetic tape production.

Vibro-Energy Grinding Mills are used in the production of ordinary items like coffee cups, floor tile and ink pigments, as well as not-so-ordinary items such as computer chips and auto exhaust sensors.

APPENDIX B

PCB EXTRACTION PROCESS

SHEET A

MILL THROUGHPUT - Double Shift, Continuous Milling

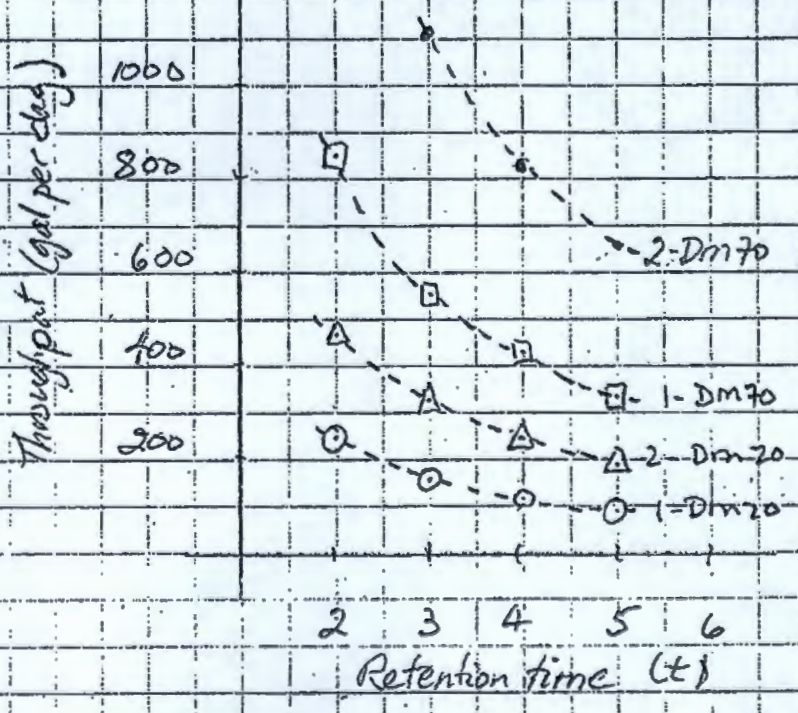
Assume: $2 - 9^h$ shifts/day
2^h mill start-up, shut down time per day
(mill is shut off at end of day - charge left in)

Calculate:

$$\text{Throughput} = \frac{\text{available milling time}}{\text{retention time}} \times \text{mill charge volume}$$

$$TP = \frac{(18-2)}{t} \times V_m = \frac{16}{t} \times V_m$$

Mill	V_m (gal)	Throughput $t=2^h$ (gal/d)	$t=3^h$ (gal/d)	$t=4^h$ (gal/d)	$t=5^h$ (gal/d)	$t=6^h$ (gal/d)	
1-Dm20	30	240	160	120	96	80	⊙
2-Dm20	60	480	320	240	192	160	△
1-Dm70	105	840	560	420	336	280	⊡
2-Dm70	210	1680	1120	840	672	560	•



JES 12/5/97

TOPS FORM 33041

The objective of this document is to examine the ramifications of adding a PCB extraction mechanism with the proposed Vibro Energy Grinding mill for the size reduction of K-Basin Sludge. Combining the size reduction step for the K-Basin sludge processing with a PCB extraction step will have the effect of reducing the total number of unit operations required to process the sludge in addition to taking advantage of the mechanical energy in the grinder to enhance the removal of PCB's prior to further processing.

The components that will be required to be added to the Vibrational Mill are an extraction solvent injector pump, a liquid/liquid separation unit, and an offgas collection/condensation system.

Process Chemistry

The sludge matrix to be processed in this program is best represented by a water matrix with significant organics in solution or as solids. As a general rule, polar solvent extraction is an obvious candidate for the removal of PCB's and other chlorinated organics from a water based system.

Two primary difficulties with liquid/liquid or liquid/solid solvent extraction are partition coefficients and solvent contacting. With a water matrix, partition coefficients are generally quite favorable for many polar solvents. In analytical extraction procedures, such solvents as hexane, dichloromethane, MEK, diethyl ether, and others, are often used to remove PCB's for capture and analysis. One of the problems with the uses of liquid/liquid extraction using these solvents is that other hydrocarbons, chlorinated organics, and VOA's are often extracted at the same time. The presents a problem for analytical processes, but would not be a problem in this case, as extracting the hydrocarbons will actually assist in the extraction process, both as a carrier solvent and by removing PCB soluble phases from the matrix.

Solvent contacting is a critical component of liquid extraction in that a large amount of surface area must be provided for the PCB partitioning to take place. In analytical methods, it has been found that the use of a sonicator or vibrator can allow very intimate mixing of the extraction and process phases by breaking up the phase interface with the vibrational wave. There are also some effects from the wave compression of the solvent phase causing localized density increases in the solvent thereby aiding extraction. The use of sonic extraction, in many laboratories, is equivalent or better to current standard methods of continuous reflux contacting, and has been shown to be successful in 1/100th of the time necessary for reflux contacting. In the vibrational grinder, this intimate mixing of solvent and the sludge medium will occur due to both the vibrational action of the liquid/liquid and liquid/solid and the entrainment of solvent in the grinding media. For this reason, it is proposed that the use of the vibrational grinder as a solvent extraction unit may prove to be highly beneficial.

Process Description

The PCB extraction enhancements to the Vibro Energy Grinding Mill would require adding solvent, removing the solvent downstream and controlling vapor emissions from the grinding unit.

First, while sludge is processing in the grinder, a mix of methyl ethyl keytone and normal paraffinic hydrocarbons (MEK/NPH) is injected into the front end of the grinder. The MEK/NPH would be added in such quantity that the solvent could intermix with the grinding media and the sludge while still retaining a free floating layer that would float on top of the mixture that should be approximately 1 to 2 cm thick. The layer of solvent on top of the process matrix should not undergo intense mixing, thereby providing a partial barrier to bulk evaporation and particulates escaping the matrix. The process mix would be taken out of the grinder through the discharge port and passed to a liquid/liquid separator. In the separator, the MEK/NPH and sludge would be allowed to separate. In some cases, depending on the matrix, an emulsion-breaking agent may be required. The MEK/NPH is then collected separately (as the upper layer), while the sludge is sent to the next unit operation for further processing. Attached to the grinder and the liquid/liquid separator would be an offgas handling system.

The offgas handling system would consist of a condenser, followed by a chevron demister, then a High Efficiency Mist Eliminator (HEME), followed by a HEPA filter, and a centrifugal blower at the end of the train used to draw vapor through the system.

The solvent, once separated from the aqueous matrix, will either have to be treated by removal of the solublized PCB's or the complete destruction of the solvent matrix. Distillation of the solvent phase may provide acceptable removal of MEK, and perhaps the separation of NPH can be accomplished to reduce the volume of the waste solvent stream from this process

Alternative 1: Alternate Solvents

The MEK/NPH system was selected due to its density less than water, its acceptable viscosity, low volatility compared to other solvents, and the affinity of MEK for PCB's. Alternate extraction solvents that could be considered include hexane/acetone (1:1), hexane/dichloromethane (85:15), diethyl ether/hexane and dichloromethane; all of which may have slightly greater affinity for PCB's than the MEK/NPH mixture.

The MEK/NPH system was considered for use as a potential solvent for PCB removal from the sludge matrix. The MEK in this system operates as a phase transfer agent to solvate PCB's from the sludge phase, and transport them to the NPH phase. Once the PCB's are partitioned into the NPH phase, they should remain there until the phases are separated. The NPH is lighter than water, which will allow it to float on the top of the sludge matrix following extraction, which will make separation much easier downstream. The cap of NPH should also combat the higher volatility of the MEK to keep much of it in solution in the extraction solvent and also act as a barrier to aerosol formation from the sludge phase being grinded.

Hexane/Acetone mixtures are often used in the sonication extraction of sediment or soil samples for PCB analysis. While this solvent could be used in this case and is a very good extraction solvent for PCB's, it may not be appropriate. This combination has a very high volatility and would evaporate too quickly during operation. In addition, the non-polar nature of the acetone would result in a large amount of acetone being soluble in the process matrix and unrecoverable. This would also lower the partition coefficient for the solvent side of the matrix. In addition, hexane is much more flammable than some of the other solvents considered here.

Diethyl ether/hexane may also prove to be too volatile. The use of dichloromethane may not be desirable in that if solvent is left behind in the matrix, it may prove to be problematic in downstream processing. However, these other solvents should be further evaluated for use, as the advantage of slightly greater affinity for PCB's may outweigh the disadvantages of higher volatility.

Alternative 2: MEK preinjection

The first alternative consists of injecting the MEK separately from the NPH. The MEK could be added in the feed pipe prior to the unit, or added to the grinder prior to adding the NPH. This would allow for initial co-mingling of the more volatile, lower viscosity solvent with the sludge matrix. This may provide better penetration of the sludge initially, then allowing the NPH addition to draw out and co-extract both the PCB's and the MEK.

Process Uncertainties

One of the primary uncertainties for this process is the ability for the system to produce an emulsion layer. Liquid extraction of any media has the potential for forming stable or partially stable emulsions that are quite difficult to break. An emulsion forms when the solvent and the extracted media mix intimately and do not separate when the system is allowed to settle. In some cases, the mixing method of a system can trap air in the emulsion and form a stable foam. This can be affected by the solvents used, the type and speed of mixing, the ionic strength of the polar phase, the viscosities of the liquids (function of temperature), and the organic loading or particulate loading in any of the phases. An effort will need to be made to examine and evaluate the potential for emulsion creation in this system, and the steps needed to combat an emulsion prior to separation of the solvent phase.

In addition to emulsion breaking, there are other separation issues that must be examined. First, the liquid/liquid separator used to remove the solvent from the process matrix must be evaluated to examine the potential for solid/liquid separation in the aqueous phase. This will need to be studied to ensure that the liquid/liquid separator does not fill up with deentrained solids. This can be accomplished in a settling evaluation that can generate data to compare to the conditions required to separate the emulsion of the solvent and process fluid.

Also, the amount of residual solvent and PCB's must be examined to determine their effect on downstream processes. A small amount of solvent will be soluble in the aqueous phase, and this

amount will have to be quantified and then evaluated to see if this is acceptable with respect to downstream processing and characterization requirements. Some small-scale solubility tests can be used to generate expected stream concentrations that can be evaluated against acceptable organic limits for downstream processing of the sludge.

Another process uncertainty for this system is the extent of the ability of the PCB's to partition into the solvent phase and how many stages this may require. Standard analytical procedures for quantifying PCB's usually require three extractions to optimally remove PCB's from a matrix. This will need to be investigated to determine the removal efficiencies of the system. Some small-scale cascade extraction cells could be used to examine the requirements for acceptable PCB removal.

Finally, I am unsure of the method that would be most useful for separating the PCB's out of the MEK/NPH solvent phase. An evaporation or distillation step may be employed to remove much of the MEK and some of the NPH, but it may be necessary to apply vacuum or other distillation adjustments to the process to keep from solvent stripping the PCB's. Some separation methods may need to be tried at a bench scale level to determine how best to separate the solvent from the PCB's.

HNF 2280 Rev 0

APPENDIX C.

MILL TRHOUGHPUT CALCULATIONS

SHEET A

MILL THROUGHPUT - Double Shift, Continuous Milling

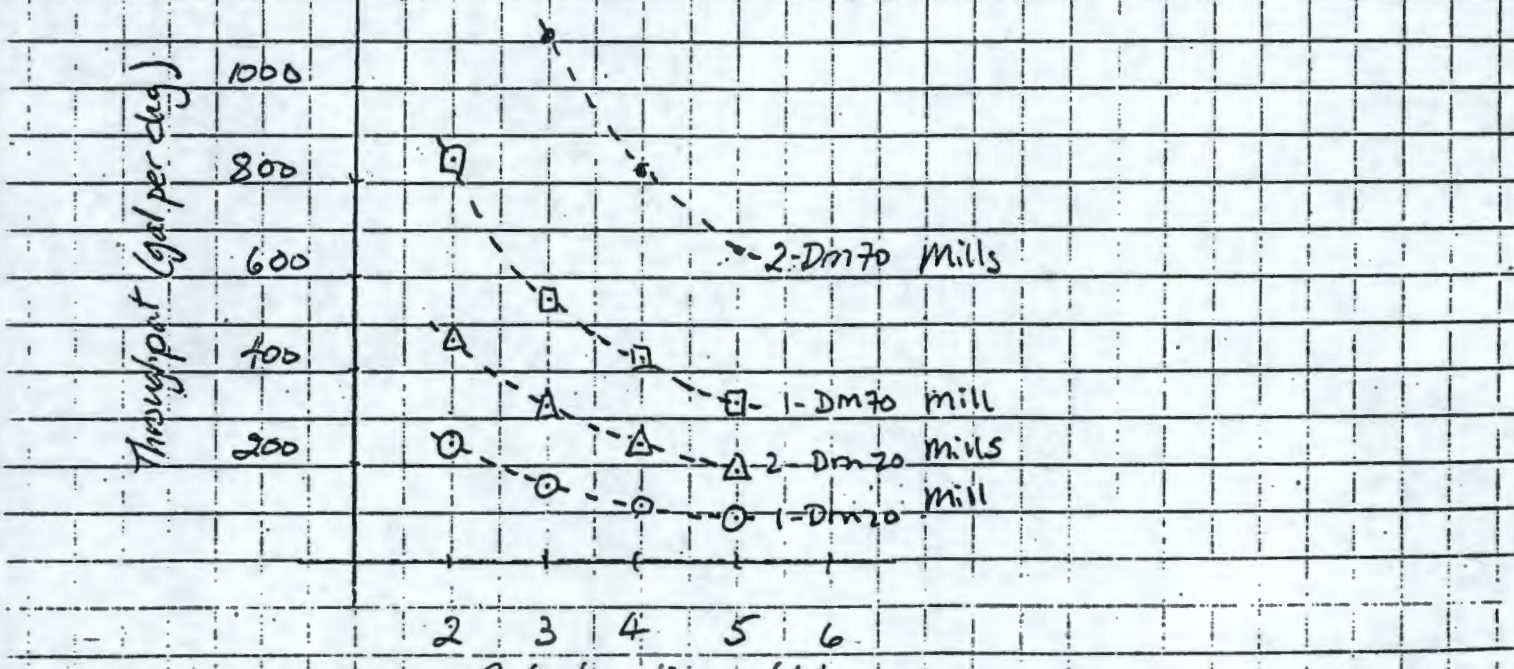
Assume: 2 - 9^h shifts/day
2^h mill start-up, shut down time per day
(mill is shut off at end of day - charge left in)

Calculate:

$$\text{Throughput} = \frac{\text{available milling time}}{\text{retention time}} \times \text{mill charge volume}$$

$$TP = \frac{(18-2)}{t} \times V_m = \frac{16}{t} \times V_m$$

Mill	V_m (gal)	Throughput $t=2^h$ (gal/d)	$t=3^h$ (gal/d)	$t=4^h$ (gal/d)	$t=5^h$ (gal/d)	$t=6^h$ (gal/d)	
1-Dm20	30	240	160	120	96	80	⊙
2-Dm20	60	480	320	240	192	160	△
1-Dm70	105	840	560	420	336	280	⊡
2-Dm70	210	1680	1120	840	672	560	•



JES 12/5/97

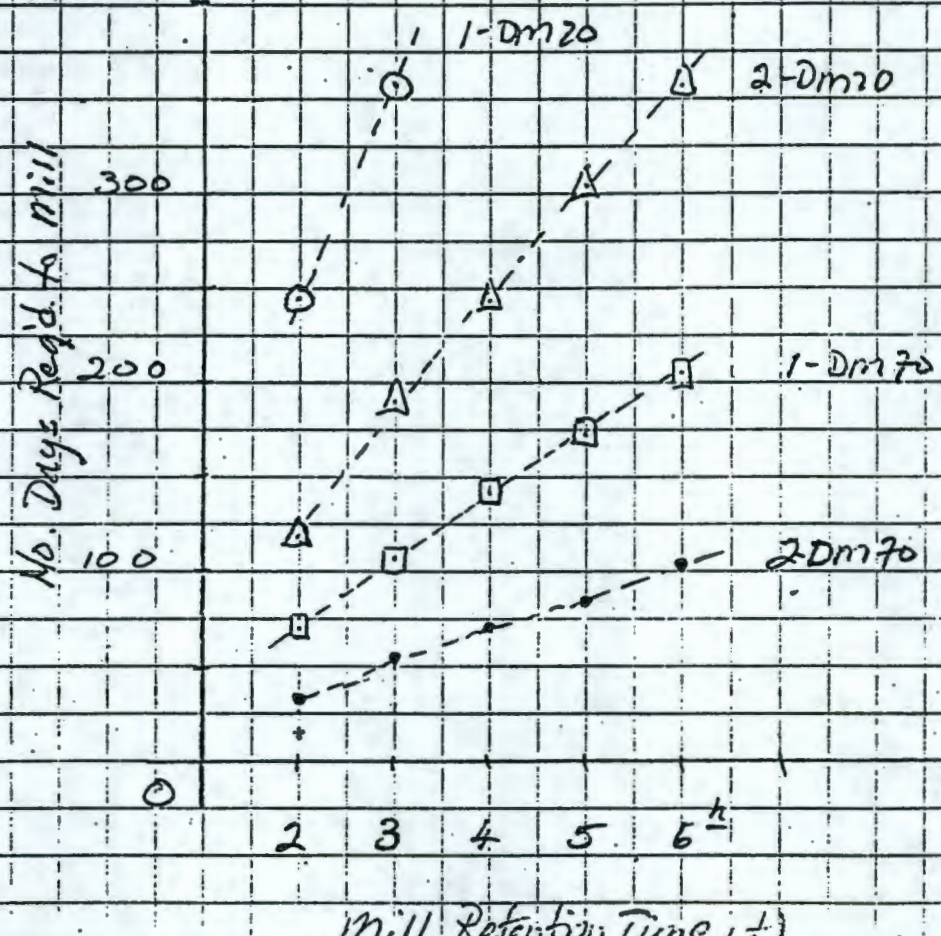
TDPS FORM 33041

MILL SIZING - Double Shift, Continuous Milling

Assume: KE Basin 52,600 gal @ 12 w/o solids
KW Basin 5,600 gal @ 33 w/o solids
Mill throughputs from Sheet A
5 w/o solids return to mill does not add significant volume

No. days req'd. to mill sludge =

$$D = \frac{\text{Volume of sludge}}{\text{Throughput per day}} = \frac{58,200 \text{ gal}}{TP \text{ gal/day}}$$



JES 12/5/97

TOPS FORM 23C41

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Facility Cleanup Projects	Date 2/23/98
Project Title/Work Order		EDT No. 621537
ALTERNATIVE CONDITIONING PROCESS FOR K-BASINS SLUDGE		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Correspondance Control	A3-01	X			
BWHC					
A. G. Westra	R3-86	X			
DESH					
C. J. Alderman	X3-85	X			
J. I. Diehl	S3-80	X			
F. W. Moore	R3-86	X			
F. J. Muller	X3-85	X			
K. L. Pearce	R3-38	X			
D. R. Precechtel	X3-85	X			
C. A. Thompson	R3-85	X			
J. E. Turnbaugh	R3-15	X			
D. J. Watson	X3-79	X			
A. G. Westra	R3-86	X			
SNF Project Files	X3-85	X			
FDH					
M. J. Wiemers	R3-86	X			
NHC					
J. P. Sloughter	H4-49	X			
Pacific Northwest					
A. J. Schmidt	K3-75	X			
A. L. Zacher	K9-08	X			