PFBC HGCU Test Facility
Technical Progress Report

Second Quarter, CY 1992

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I. INTRODUCTION

This is the eleventh technical progress report submitted to the Department of Energy (DOE) in connection with the Cooperative Agreement between DOE and Ohio Power Company for the Tidd PFBC Hot Gas Clean Up Test Facility. This report covers the period of work completed during the Second Quarter of CY 1992.

The following are highlights of the activities that occurred during this report period:

- The Tidd combustor internals were modified to connect the hot gas system for slipstream operation. For the initial operation and checkout of the system, only the bypass cyclone was connected. The APF was isolated.
- Various pre-operational activities were completed, including pneumatic leak testing of the HGCU system, operation of the closed cycle cooling water system, operation of the back pulse compressor and air pre-heater, and checkout of the back pulse skid.
- Initial operation of the system using the bypass cyclone occurred during May 21-23, 1992. Ash removal using the bypass cyclone appeared to be satisfactory. However, several hot spots appeared in the piping system and on the cyclone. Some expansion joints exhibited elevated temperatures.

- On May 23, 1992, an expansion joint ruptured, forcing the unit to be shut down. The failure was later determined to be due to stress corrosion. Another expansion joint bellows was found to have pinhole leaks on the bottom side of some convolutions. These leaks were due to pitting corrosion resulting from chlorides in condensed flue gas.
- Following the expansion joint failure, a complete engineering review of the system was undertaken and is continuing. As a result of this review, several enhancements will be made to the system before it is returned to service. The modifications are discussed elsewhere in this report.
- Contract Modification No. 6 was issued to Westinghouse during this quarter. This modification is for APF surveillance testing services.
- A purchase order was issued to Battelle for ash sampling hardware and testing services.

Project status as of June 30, 1992:

All original engineering, procurement and construction activities were completed during this period. However, as a result of the expansion joint failure and subsequent engineering review, these activities have resumed. The hot gas piping was dismantled and removed from the combustor building. The expansion joint assemblies were returned to the manufacturer for disassembly and inspection.

If the proposed modifications to the system can be completed as scheduled, operation of the system should resume in November, 1992.

II. WORK ACCOMPLISHED DURING THE REPORTING PERIOD

2.1 Detailed Design - Engineering

In addition to the items listed under Paragraph I, the following major items were completed this quarter:

- Visited PX Engineering Co. on two occasions in April, 1992 to expedite delivery of internal piping for tie-in outage.
- Performed field walkdowns of various systems.
- Worked with plant to modify hot gas damper valve flanges to eliminate flange leaks.
- Attended several pre-op meetings at Tidd to discuss pre-op activities.
- Issued pre-op procedures for purging and flushing piping systems.
- Followed initial operation of the system at Tidd.
- Investigated expansion joint failure and visited vendor shop to witness disassembly of the expansion joints.

- Investigated modifications for the HGCU system as a result of the expansion joint failures.

2.3 Westinghouse Engineering & Design

See Appendix 1.

3.2 Test Plan

Two normal operating procedures were issued during this quarter:

"HGCU Ash Removal System"

"HGCU Closed Cycle Cooling Water System"

One normal operating procedure was written and routed for internal review during this quarter:

"HGCU Advanced Particle Filter System"

The preliminary HGCU Test Plan was revised and approved. An outline for the Detailed HGCU Test Plan was also approved and a draft of the Detailed Test Plan is being prepared.

4.2.1 Ducting

From observations made during and after initial operation of the system, certain deficiencies became evident in the design of the hot gas piping system, as listed below:

1. Hot spots appeared at various points in the system, indicating that the insulation was not packed tightly enough in those areas or that a gas leak path into the piping annulus had formed.
2. Several expansion joint bellows exhibited elevated temperatures (250F to 670F) during operation, again indicating inadequate insulation or gas flow into the piping annulus.
3. Corrosion of Type 321 stainless steel expansion joint bellows was evident upon disassembly of the joints. The failure of one joint was attributed to stress corrosion cracking, while the pinholes found in another bellows was due to pitting corrosion. Chlorides were found in the condensed flue gas in the insulation material.
4. Corrosion was also found on carbon steel surfaces that did not have the Plasite coating which was applied to the inside of the outer pipe. These areas included flange faces inside the gasket area, various nozzles on the cyclones, and the top edges of the damper valves. This corrosion is believed to be from sulfuric acid formed from the flue gas condensation.

After reviewing the above problems and lengthy discussions with other users of hot gas piping systems, consultants, and others, the following piping modifications were decided upon:

1. Change the expansion joint bellows material from 321 SS to Hastelloy C-22. This is a high nickel alloy that is claimed to have outstanding resistance to pitting, crevice corrosion, and stress corrosion cracking in the presence of oxidizing agents and chlorides.
2. Use a 2-ply expansion joint bellows with pressure monitoring capability between the plies. The inner ply would be 0.038" thick and the outer ply would be 0.062" thick. Failure of the inner ply would not result in failure of the joint and could be detected with a pressure alarm.
3. Replace the ceramic fiber insulation with a cast refractory. It was concluded that a cast refractory would present a more solid barrier to gas flow behind the inner liner into the annulus than ceramic fiber blanket insulation. It was further decided to retain the inner liner (except in two instrument spools) to preclude refractory from spalling off and getting carried into the gas turbine. As additional enhancement, 1/4" thick ceramic fiber rollboard insulation will be used on the ID of the cast refractory for expansion and cushioning.

The refractory selected has a density of 50 lbs/ft³ and a thermal conductivity which should keep the outer pipe temperature below 250F.

4. Apply a corrosion resistant material to the inside of the outer pipe. In order to ensure that corrosion of the outer pipe would not be a concern, it was decided to clad the inside surfaces of all piping and flange faces with Hastelloy C-22. The cladding will be 16 gauge (1/16" thick) and applied to the pipe ID by plug welding.
5. Modify the liner end connection collars to minimize gas leaking behind the liner. One end of the collar will be seal welded to the liner where possible. All expansion of the liner will occur on one end of the pipe.

4.3 Westinghouse APF

We requested Westinghouse to review the potential for corrosion of the 310 SS thermocouples and pressure sensing tubes inside and outside the APF. Also, the carbon steel blind flanges which contain the instrumentation will be reviewed.

See Appendix 1 for other activities.

4.4 APF 2

See Appendix 1.

4.5 Backup and Bypass Cyclones

Following initial operation of the system, both cyclones were opened and inspected by the manufacturer, refractory supplier, and refractory installer. Some cracking of the refractory was apparent, but was not considered to be serious. The refractory plugs used to fill the manway holes have a metal shroud which acts as a heat conductor to the manway nozzle. We are investigating modifying these plugs to eliminate this problem. Some corrosion was evident on the manway nozzle and flange. We are investigating the feasibility of applying a Plasite corrosion resistant paint to these surfaces.

4.8 Ash Removal System

4.8.1 APF Ash Cooling

Installation of the screw cooler and closed cycle cooling water system (CCCWS) is complete. During June 15 through 18, a Denver service representative was on site to assist with flushing and test operation of the screw cooler lube oil and hydraulic systems. Additional testing of the hydraulic system, including speed control of the screw, is required and will commence during Third Quarter, 1992. Flushing and test operation of the screw cooler CCCWS has also been completed during this quarter.

4.8.2 APF Ash Depressurization

Installation of the APF ash removal system (including lockhopper, surge hopper, and ash transport piping) was completed this quarter. Flushing and test operation of the system has also been completed.

4.8.3 Cyclone Ash Removal

Installation of the cyclone ash removal system was completed this quarter, including installation of the new cyclone ash air swirlers in the cyclone bottom plug assemblies.

4.12 Special Instrumentation

The ANARAD gas analysis system was received in June, 1992, but has not yet been installed.

A purchase order was issued to Battelle for ash sampling hardware and testing services. A site visit was being planned at the time of the expansion joint failure and had to be postponed to a later date.

4.13 Computer/DABAS

Checkout of all configurations prior to running the system has been completed. The POPS system software is completing checkout. This is being installed as time permits while the plant is running. Annunciator database review is proceeding.

Pre-operational meetings were held weekly while construction was in progress.

III. MANPOWER REPORT AND COST DATA

As of June 30, 1992, the AEPSC Engineering, Design and Project Support cumulative work-hours were 53,740 or 93.9% of the total 57,209 currently projected for the project. Figure 1 compares the actual work-hours expended versus the current estimate. For the reporting period, a total of 5,207 hours were charged to the project by AEPSC personnel.

The actual DOE's cost expenditures during the Second Quarter, 1992 were \$3,167,173. As of June 30, 1992, the cumulative DOE's cost expenditures were \$11,378,540. Figure 2 depicts the cumulative expenditure forecast for the project which includes Westinghouse's cost-share. During the Second Quarter, 1992, Westinghouse was paid a total of \$770,202. Total payments to Westinghouse through June 30, 1992 were \$4,573,677. Major contractual commitments during this reporting period totalled \$132,914 and are summarized as follows:

<u>Reference</u> (Contract/Purchase Order)	<u>Description</u> (Contractor)	<u>Contracted Costs</u>
28164-2	APF Efficiency Testing (Battelle)	\$101,114
03212-2	Spare Boards for OSI 20 (Bailey Controls Co.)	\$ <u>31,800</u>
		\$132,914

Figure 1

PFBC HOT GAS CLEAN-UP TEST PROGRAM

AEPSO ENG, DESIGN & PROJECT SUPPORT WORK-HOURS
BUDGET VERSUS ACTUAL

Figure 2

PFBC HOT GAS CLEAN-UP TEST PROGRAM

CUMULATIVE EXPENDITURES
BUDGET VERSUS ACTUAL

CUMULATIVE EXPENDITURES
(\$000)

	Budget	Actual
3Q/89	18.7	70.1
4Q/89	70.1	106.3
1Q/90	106.3	152.3
2Q/90	152.3	383.1
3Q/90	383.1	1142.4
4Q/90	1142.4	2108.4
1Q/91	2108.4	3120.3
2Q/91	3120.3	5213.0
3Q/91	5213.0	8220.2
4Q/91	8220.2	12683.5
1Q/92	12683.5	14656.2
2Q/92	14656.2	16524.3
3Q/92	16524.3	18106.5
4Q/92	18106.5	19483.3
1Q/93	19483.3	20039.8
2Q/93	20039.8	20372.3
3Q/93	20372.3	20672.6
4Q/93	20672.6	20898.9
1Q/94	20898.9	20955.5
2Q/94	20955.5	

APPENDIX 1

ADVANCED PARTICLE FILTER

Technical Progress Report No. 8
April through June 1992

Prepared by

Westinghouse Science and Technology Center
Pittsburgh, Pennsylvania

For

American Electric Power Service Corporation
Columbus, Ohio

AEPS Contract No. C8014

TIDD ADVANCED PARTICLE FILTER

GENERAL

Startup activities during this quarter have been delayed pending revision of hot gas piping by AEP. All milestones have been completed on or ahead of the required schedule with the exception of the acceptance test. A number of miscellaneous final installation details have been accomplished. A large gap at the weld prep for the APF vessel flange was resolved by installing an appropriately sized insert and making two seal welds. Leaks from back pulse skid ball valves have been stopped by replacing gaskets and, in select cases, by pipe realignment. Factory installed o-ring seals have been repaired in a pulse solenoid valve. (The valve will be reinstalled pending site access to the skid.) Clogging of the first stage drain line in the pulse air supply compressor has been eliminated by replacing the line with one of larger diameter.

TIDD APF SYSTEM DESIGN AND SUPPLY

Table 1 provides an overall status summary by major component. At this time all procurement is complete.

Table 1 - Summary of AEP/APF Major Procurement Activity

<u>Item</u>	<u>Reference Drawings</u>	<u>Supplier and Address</u>	<u>Scheduled Delivery</u>	<u>Purchase Order No.</u>
1. APF Vessel, Flange Internal Liners and Piping	1302J20 1302J21 1505E61	Penn Iron Works 700 Old Fritztown Rd. Montrose Manor Reading, PA 19608	2/4/92 • Complete	34-38901-PA (12/12/90)
2. Refractory Lining	1302J22	BMI 27 Noblestown Rd. Carnegie, PA 15104	2/4/92 • Complete	34-35890-PA (2/12/91)
3. High Alloy Materials		Rolled Alloys Box 310 Temperance, Michigan	• Complete	34-39644-PA (12/04/90)
4. Tubesheet Structure	1505E87	Alloy Engineering Co. 844 Thacker Street Berea, Ohio 44017	2/6/92 • Complete	34-42824-CM (3/21/91)
5. Candle Cluster and Mounts	1505E85 1505E26 1D33216	FC Machine Tool & Design 1474 Main Street Cuyahoga Falls, Ohio 44221	2/11/92 • Complete	34-38950-CA (2/12/91)
6. Candle Elements		Schumacher GmbH & Co. Zur Flugelau 70 Postfach 15 62, D-7180 Crailsheim, Germany	2/13/92 • Complete	34-39379-CM (12/03/90)
7. Pulse Compressor	1505E62	Norwalk Company, Inc. Box 5 N. Water Street South Norwalk, CT 06856	1/20/92 • Complete	34-40424-PM (1/30/91)
8. Instrumentation and Controls	1505E73 (1-2) 1505E74 1505E75 1505E76 (1-3) 1505E94	Varied	1/16/92 • Complete	Varied

KARHULA ADVANCED PARTICLE SYSTEM

GENERAL PROCUREMENT

Candle filters, candle gaskets and hot seal plate to tubesheet gaskets are manufactured and ready for shipment to our exporter. All materials for cluster and hot seal plate assembly have been delivered to the respective fabricators.

Difficulties were encountered in qualifying and ultrasonic inspection of the plenum final closure weld. Refinement of use of shielding gas has provided optimization of the welding procedure. Preparation of special mockups has provided enhanced calibration for the inspection procedure. Machining is 90% complete and weld fabrication is 60% complete. Shipment is projected to be on or close to schedule.

Difficulties were encountered in scheduling of expansion cone radiography for the hot seal plate. Two minor but rejectable linear indications are being repaired in this component. Machining is 50% complete and weld fabrication is 70% complete. Remaining work is being expedited to compensate for several days of schedule slippage.

PROOF-OF-CONCEPT TESTING

As reported in the previous quarterly, 146 hours of testing including 43 cycles had been completed using Karhula ash and Coors candles. A report on this testing was completed, and is included in the Appendix.

Subsequently, an additional supply of flyash was received from Ahlstrom, and tested to verify consistency of filtration performance and candle cleanability.

Consequently, the Westinghouse HTHP test facility was set up with five 1.5 meter Coors candles and the new ash feed for testing.

Conditions:

Temperature	1500 to 1550°F
Pressure	100 psig
Face velocity	5.6 ft/min
Dust loading, inlet	10,000 ppmw
Test duration	70 hours
Cycles completed	11

The initial candle pressure drop was 15 iwg. The trigger pressure drop for blowback was set at 40 iwg. All five candles were blown back as a group with a single pulse into the common plenum. Blowback tank pressure was 220 psig, with baseline pressure drops of 16 to 19 iwg. The stable low baseline pressure drop and straight pressure drop ramps after each blowback were evidence of successful operation, and were consistent with prior results. Dust penetration was negligible throughout the test period, averaging 0.5 ppmw.

Cycle lengths were about twice those observed with the previous Karhula ash, indicating an even lower flow resistance.

APPENDIX A

WESTINGHOUSE CANDLE FILTER CLUSTER TEST IN
KARHULA PCFB TESTING FACILITY

PROOF-OF-CONCEPT TEST REPORT

1. INTRODUCTION

Westinghouse is to provide a candle filter cluster for proof-of-concept testing in the Ahlstrom Karhula PCFB test facility.

There are two major differences in the Karhula application relative to prior experience. First, Coors mullite candles will be used for the first time on this scale. Second, blowback pressure will be limited to 40 bar (588 psi), which means that confirmation of cleanability of these new candles with lower pulse intensities than previously utilized was needed. In addition, the character of the Karhula ash will of course be different from the ash of other systems.

Using existing Westinghouse models and facilities, testing was conducted to evaluate the potential risk regarding filter cleaning due to the limited blowback pressure capability that exists at the Karhula facility. This evaluation consists of:

- 1) Characterization of the Karhula test environment, including pulse air capacity, operating conditions, and ash properties
- 2) Projections of filter cleanability and cleaning requirements, based on this information and Westinghouse know-how

- 3) Proof-of-concept tests to confirm filter cleanability projections
- 4) Working with Ahlstrom to assure that the pulse cleaning system is configured to maximize probability of successful filter system testing.

The results of this evaluation are summarized in this report.

2. CONCLUSIONS

- Westinghouse has evaluated the Karhula filter application and concludes, based on the implementation of the recommendations of this study, that the technical risks are not greater than in other applications. Consequently, Westinghouse recommends proceeding with filter system supply.
- The blowback system as finally evolved in discussions between Westinghouse and Ahlstrom is felt to provide an adequate pulse intensity margin, which is projected to provide effective cleaning.
- The Karhula ash samples tested to date suggest that this ash is a well behaved and cleanable material. However, uncertainty always exists with regard to how an ash will actually behave in a real process environment.
- The Coors mullite candles have performed well in bench-scale testing, although long-term performance has not yet been ascertained.

3. KARHULA TEST ENVIRONMENT

3.1 Operating Conditions

Operating conditions assumed for the filter blowback system design analysis were as follows:

Pressure	174 psia (11.8 atm)
Temperature	1615°F (880°C)
Flow rate	40,000 lb/hr (18,000 kg/hr) = 2900 acfm (82 m ³ /min) at above conditions
Dust loading	up to 30,000 ppmw

With a Westinghouse filter cluster of total filter surface equal to 390 sq ft (36.2 m²), a nominal face velocity of 7.4 ft/min (3.8 cm/s) is anticipated. If the same mass flow rate is maintained with operation at the minimum expected pressure of 145 psia (10 atm), the face velocity will rise to 9 ft/min (4.6 cm/s).

3.2 Ash Characterization

A sample of ash from Karhula was obtained prior to this program, and has been used in testing to date. The following information was derived in earlier laboratory measurements:

- The tested ash sample had a mean particle size of approximately 7.7 microns measured with a Coulter counter with a 100 micron aperture. This is considerably larger than other ashes (2 to 5 microns) previously tested by Westinghouse. In general, easier cleanability correlates with larger particle sizes.

- The flow resistance of this material has been measured as 0.6 psi (4.1 kPa) per 0.1 inch (2.5 mm) of cake thickness at 1500°F (815°C) and 10 ft/min (5.1 cm/s). This is less than the resistance of other materials tested by Westinghouse (1 to 6 psi, 7 to 40 kPa). Low flow resistance correlates with easier cleaning.
- The material is basic, i.e it has a low iron to calcium ratio. Acidic materials are more difficult to clean, presumably because of "tackiness" of iron compounds.
- The ash was tested (100 hr, 150 psig (11 bar), 1500°F (815°C), 5.6 ft/min (2.8 cm/s)) in conjunction with three 1-m Schumacher candles, and cleaning was effective.

The evidence suggests that this ash should be relatively easy to clean from candles.

The ash to be encountered at Karhula may behave similarly, or it may be more difficult, depending on coal and sorbent feedstocks and on the gaseous chemical environment.

3.3 Karhula Pulse System

"Pulse intensity" is defined as the peak pressure difference generated by a cleaning pulse, measured between the inside of the filter (high) and the dirty-side (low). Part of this pulse intensity is consumed by pressure drop across the wall, with the remainder being taken up across the cake. In order to clean a filter cake from a filter surface, a blowback pulse must generate a pressure drop across the cake in excess of the adhesive force per unit area binding the cake to the filter surface.

The pulse intensity achieved is determined by the design of the blowback system. Higher pressure in the blowback tank enable high pulse intensity, as does minimized flow resistance in the piping and valving to the pulse nozzle. Flow can also be limited by sonic flow at the minimum inside diameter in the pulse piping system.

The blowback compressor at Karhula is limited to 40 bar (588 psia) discharge pressure. This is considerably less than the pulse pressure capacity of similar systems for which Westinghouse has provided the blowback compressor. In those systems, 1500 psig blowback capacity is typically provided, with expected operation in the 700 to 800 psig range. These conditions provide design margin and are consistent with available commercial solenoid valve sizes. Thus there was concern that insufficient pulse pressure would be available at Karhula.

The maximum flow capacity of the Karhula compressor is 1580 lb/hr (200 g/s) which is well in excess of any foreseeable blowback requirement. The existing blowback piping featured a large blowback tank, 230 ft³ (6.5 m³), and large diameter piping, 6-inch (150 mm) or more, up to an existing fast-acting 6-inch (150 mm) ball valve (Cv=1000, 0.4 sec to open or close).

3.4 Coors Candles

The flow resistance of virgin Coors candles has been measured at 0.8 psi at 1500°F and 10 ft/min. This is double the virgin resistance of Schumacher SiC candles. Consequently there was concern that a higher pulse intensity would be required to remove the filter cake, in order to overcome the flow resistance of the filter itself.

4. PRELIMINARY ANALYSIS

Initial pulse system performance assessments were made using Westinghouse pulse cleaning models, assuming the use of Atkomatic 2-inch solenoid valves for pulse control. This is the largest high pressure solenoid valve commercially obtainable. Coors candles are assumed to be conditioned to a flow resistance of four times their virgin resistance, an assumption based on experience with Schumacher candles.

Estimated required tank pressures were 500 psig to 600 psig (34 to 40 bar), depending on design of internals, and cake (pressure drop) buildup allowed between pulses. This was felt to provide insufficient margin with regard to maximum available pressure.

Pulse intensity is limited by flow through the rather small diameter valve. Maximum achievable pulse intensity (no cake) was estimated as approximately 170 inches of water (42 kPa) at 575 psig (40 bar) blowback pressure.

It was desired to show that this pulse intensity was sufficient to clean Karhula ash from Coors candles in the Westinghouse PFBC simulator filter test facility.

5. TESTING

The Westinghouse HTHP test facility was set up with five 1.5-meter Coors candles and Karhula ash feed for testing. The candle array test plenum design used was identical to that previously used for the Tidd ash with Schumacher candles.

The blowback system in the test facility is superior to what is possible in a full cluster application such as at Karhula. This is primarily because a highly efficient, narrow-throat eductor is used. Such an eductor is not possible in a larger installation because of pressure drop limitations during normal filtration flow with much higher gas flow rates (more candles, same face velocity).

The Westinghouse blowback model was used to determine that a test facility blowback tank pressure of 200 to 250 psig (15 to 18 bar) would give a pulse intensity about that of the maximum estimated for Karhula using the 2-inch solenoid valves. Consequently, a primary test objective was to demonstrate that stable cleaning, as determined by stable baseline pressure drops, could be achieved using tank pressures of no more than 250 psig.

The following were the test conditions:

Temperature	1500 to 1550°F
Pressure	100 psig
Face velocity	5.6 ft/min
Filtration/blowback cycles	43
Dust loading, inlet	5,000 ppmw (cycles 1 to 3) 10,000 ppmw (cycle 4 to 43)
Test duration	146 hours

The virgin candle pressure drop was 13 iwg. The trigger pressure drop for blowback was set at 40 iwg. All five candles were blown back as a group with a single pulse into the common plenum. Blowback tank pressures were varied over the range of 150 to 400 psig, with excellent cleaning, as indicated by stable low baseline pressure drop, and by straight pressure drop ramps after each blowback. The following is a summary of baseline pressure drop performance versus cycle and tank pressure.

<u>Cycles</u>	<u>Tank Pressure, psig</u>	<u>Baseline Pressure Drop, iwg</u>
1-12	250	15.8 to 17.8
13-14	400	19.2 , 19.1
15	250	19.2
16-20	400	19.2 to 19.4
21-27	250	19.8 to 19.4
28-29	200	18.2 , 18.3
30-40	150	19.0 to 20.4
41-43	200	19.9 to 19.2

Dust penetration was very low throughout the test period, averaging 0.55 ppmw.

Overall, the testing confirmed that the cleanability of the tested ash was very good, and that the candles performed well. Candle baseline pressure drop increased only 50% relative to original levels.

While the above results are encouraging, it must be remembered that tests were done by reusing a single drum of Karhula ash multiple times. It is possible that this reduced the tenacity of the dust cake. Also, it is possible that candle baseline resistance could increase further with increased exposure time, or due to the presence of aggressive chemical vapor species in the Karhula application.

6. IMPROVED BLOWBACK SYSTEM PLAN

While testing showed apparent good behavior of Karhula ash and Coors candles, the result was confirmation only of marginal adequacy of blowback with Karhula's limited tank pressure and the 2-inch solenoid

valves. Given uncertainty regarding actual ash properties to be encountered, increased pulse intensity capability was felt to be necessary prior to Westinghouse commitment to filter system supply.

Consequently, Westinghouse and Karhula developed the approach of using the existing Karhula 6-inch (150 mm) fast-acting ball valve to control pulsation. Ahlstrom personnel feel this valve has sufficient reliability. This valve will service all three plenums in the filter system, with each pulse being directed to a specific plenum by computer operation of 4-inch full port ball valves in a pulse manifold (Figure 1).

This approach leads to a projected required tank pressure at Karhula of only 275 psia (19 bar), which provides a substantial and acceptable margin. With this blowback system, and a 575 psia tank pressure (40 bar), the estimated maximum pulse intensity with no cake is 950 inches of water (235 kPa).

PULSE SCHEME USING EXISTING FAST ACTING VALVES

- All manual valves are normally in open position.
- Automated valves A, B and C are normally closed.

To Clean Candle Cluster:

- Plenum No. 1
- Open Valve A
 - Actuate Main Valve
 - Close Valve A

- Plenum No. 2
- Open Valve B
 - Actuate Main Valve
 - Close Valve B

- Plenum No. 3
- Open Valve C
 - Actuate Main Valve
 - Close Valve C

Figure 1

END

**DATE
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11/02/93