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REPORT OF THE IEA COAL LIQUID MIXTURES TECHNICAL COMMITTEE

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IEA IMPLEMENTING AGREEMENT ON COAL-LIQUID MIXTURES (CLM)

The IEA Implementing Agreement on Coal-Liquid Mixtures was established in 1980 to undertake the collaborative development of technologies related to coal-liquid mixtures.

The initial participants were Canada, Japan, The Netherlands, Spain, Sweden, UK and the USA, with Italy joining later.

ANNEX I

Annex I is now completed. It involved surveys on the potential for CLM conversion in Canada, Japan, The Netherlands, Sweden, UK and USA. This was achieved by analyzing data on all boilers and process combustors having greater than 50 GJ/h thermal input. A compendium of all these data is available from IEA.

ANNEX II

Entitled "Cooperation in the exchange of base technology information for coal liquid mixtures". This annex has been the most active. Members from participating countries usually meet twice yearly for information exchange meetings and pertinent site visits.

Following is an extract from the 1986 Annex II annual report to the executive committee, which when finalized will be passed to the IEA in Paris as a record of achievement. Participating countries are: Canada, Italy, Japan, The Netherlands, Spain, Sweden, and the United States.

OBJECTIVE

The objective of Annex II is to stimulate the orderly and equitable exchange of technical, economic and environmental data relating to the research, development and application of coal-liquid mixture technology and to provide a forum for such exchange.

ACTIVITIES DURING 1986

A meeting was held at the Office of IEA Coal Research, London, UK, on June 24, 1986, which included member country presentations by designated contractors or delegates. A special topics meeting was also held June 25 on the economic aspects of CLM conversions. Special topic meetings have been

held jointly with the technical committee meeting since 1984. The meeting on economics proved useful since the technology is approaching maturity in a number of key areas. Site visits also were arranged of two boiler/burner companies involved in CLM technology development. It was agreed at the London meeting that the next meeting would be held in Italy at the time of an IEA sponsored workshop on CWM developments. Canada was operating agent for 1986 and Italy took over in 1987.

PROJECT STATUS SUMMARIES:

CANADA

Preparation, combustion and characterization of coal-liquid mixtures - progress in 1986.

Objective and Scope

The project comprises seven tasks in the areas of CLM preparation, combustion and characterization which began in 1982. Each task may be adopted to the changing requirements of the Canadian program and is reported on that basis. Some tasks are related to the utility boiler demonstration program and the remainder are industrial applications of coal-water mixture (CWM) technology or part of the in-house and contract support program of the federal government through its various agencies.

The objective of the program is to provide information on the preparation, handling, transportation, combustion and utilization aspects of CLM to allow the fuel to replace oil and gas whenever it is economic. A specific target is the Atlantic utility sector which depends on offshore oil, and industrial boilers and process combustors across Canada which are currently using oil and gas. The program also seeks to encourage the use of CLM in the utility and industrial sectors through progressively larger demonstrations of the technology in collaboration with industry.

JAPAN

Objective and Scope

The Japanese project on highly loaded coal-water mixture (HCWM) has been conducted by EPCD to expand the use and to simplify handling of coal. Since 1980, R&D on HCWM covers all processes from mine site to boiler and is divided into six tasks:

1. slurry preparation
2. pipeline transportation
3. storage
4. coal cleaning
5. shipping
6. combustion

The R&D work, subsidized by the government, began in 1982 as a joint project with heavy industry manufacturers and surfactant suppliers. Pilot-plant tests will be continued in order to obtain the data necessary for future demonstration stages.

SWEDEN

Generation situation

The low price of oil has caused a decrease in oil substitution activity in industry. This has led to a significant decline in business opportunities for CLM during 1986. It was very difficult for the CLM producers to supply fuel to existing customers as agreed without a loss or, at least, generating enough revenue to cover capital costs for CLM production facilities.

Government R&D spending on CLM has also declined. As a result of the commercial situation and because of a shift in the government's R&D policy to concentrate more on basic energy (with an emphasis on universities), only three companies are competing on the domestic CLM market. However, to guarantee the survival of the CLM industry the government has allocated funds

for technology development. These funds are mainly for two companies which are actively involved in marketing CLM technology as a Swedish export.

UNITED STATES

Combustion characterization

Objective and Scope

This research project, which began in September 1982, is intended to provide sufficient data on CWM chemical, physical, and combustion properties to assess the potential for commercial firing in utility large-scale industrial boilers and furnaces designed for oil firing. The project is divided into six tasks:

1. selection of candidate fuel
2. bench-scale characterization tests
3. preparation of CWM for tests
4. atomization and burner tests
5. ash deposits on performance tests
6. commercial application and economics

System component characterization

Objective and Scope

This project addresses the supply of fuels to the developers of advanced combustion system technologies. The objectives are to examine the U.S. coal resource base and select from that base a suite of coals that has sufficient resources and specifications such that they would be viable candidates for firing in future commercial installations; fully characterize the parent coals and CLM; and supply the coal-based fuels to specific contractors in the quantities required for testing. The project is expected to last three years. Topical reports on the resource base analysis and the fuel characterization will be issued as well as a comprehensive final report.

THE NETHERLANDS

Preparation and combustion of highly loaded coal-water slurry

Objective and Scope

The two offices responsible for government sponsored R,D&D on energy in The Netherlands cooperated in the following CWM related topics:

1. slurry preparation
2. use of CWM in an industrial type boiler or kiln
3. characterization of CWM
4. furnace tests to assess the sulphur capture potential of adding limestone/lime to a CWM flame

This work was based on the prevailing opinion of the government in 1985 that CWM, if fired in an environmentally acceptable way, has a good potential for replacing oil and gas as an alternative fuel in industry and in the long term has domestic application.

ITALY

Preparation, combustion and characterization of coal liquid mixtures - progress in 1986

Objective and Scope

The Italian program has the following objectives:

1. Operation of CWM production pilot plants for:
   - optimization of production costs
   - test functionality of installed materials and components
   - production of CWM from various coals
   - understanding the know-how for the construction of larger plants
2. Combustion tests on small industrial boilers for:
   - selecting industrial burners
   - atomizers wear and life

- effect on combustion efficiency of parameters such as air combustion temperature, fuel pre-heating, atomizing media
- appraisal of instrumentation and component behaviour

3. Development of CWM long distance transporation technologies to optimize transportation parameters
4. Fuel boilers retrofitting:
   - optimization of combustion efficiency
   - derating evaluation
   - ash characteristics
   - problems related to prolonged operation of the plant
5. Coal water mixtures utilization in the steel industry
6. Environmental aspects - evaluation of benefits with respect to the use of heavy oil and pulverized coal.

The purpose of the program is to substitute, wherever possible, fuel oil with CWM, mainly in the electrical sector (large boilers) where fuel oil energy consumption still prevails with respect to other fuels. Other objectives are production, supply flexibility and reduction of environmental impact.

ADDITIONAL ACTIVITIES

Another way in which information can be generated and exchanged under an IEA annex is through cost-shared work. Such a project was initiated and completed by Canada and The Netherlands in 1983 at the International Flame Research Foundation in The Netherlands. Seven coal-water mixtures of various coal types and from different manufacturers were each optimized and flame and heat transfer parameters were obtained. The work is described in reference 32 in the Italian summary document on international activities of this workshop and was conducted as part of Annex II. In 1984, the Annex II technical committee decided to hold special topics meetings (STM) in conjunction with the technical committee meeting. These have proven to be extremely useful as they have dealt with topics of similar concern and interest at the time of the meeting.

Following is a list of special topic meetings (STM) which have been held during the past 3 years:

1984 Atomization, Combustion (2 meetings),
1985 Coal Cleaning, Transportation and Handling (2 meetings),
1986 Economics of Conversions,
1987 Environmental Aspects.

In 1988 the STM will be on Transportation and Small Scale Applications. The most recent STM was held last week in Castel-Gandolfo on May 8, 1987 and the following is a summary of the presentations, with a list of participants.

CANADA

The Canadian CWM Program: Environmental aspects, by H. Whaley

Pilot-scale baghouse tests were conducted on the No. 1 10 MWe unit at Chatham, N.B., to assess bag material and gain operating experience. The pilot baghouse extracted (1) 25 500 m^3/h of the (2) 81 500 m^3/h total gas volume at 150°C. Three materials were tested; Nomex, polyester and fibreglass. The fibreglass was the most resilient. The information gained was used in the design of the baghouse for (3) 170 000 m^3/h of gas at Charlottetown, PEI. ESP's were not selected because the fly ash contains about 50% carbon (the CWM only having 1.7% ash) which makes ESP collection difficult.

In other environmental studies, calcium-based sorbents have been tried with the fuel, gaining only marginal success (about 25% capture at 1-2 molar ratio, Ca/S).

It is intended to try $CaCO_3$ injection into the baghouse to augment sulphur capture. This has been tried in Austria on a pulverized coal fired unit with some success.

ITALY

Italian Environmental Activities Related to CWM, by M. Gobbi

Interest in the environmental aspect of the use of CWM is very high in Italy, due to the growing concern with pollution problems. For this reason, the environmental impact is always taken into account in the numerous initiatives which are underway. The most interesting aspect reported during the presentations at the STM was related to combustion; the effect of transportation and preparation were considered.

Preparation

The effect on the environment is related to:

- Coal cleaning (beneficiation process) with the purpose of reducing the ash and sulphur content of CWM produced. Eniricerche is developing an original process based on agglomeration that has already been presented at the coal cleaning session. A 3 t/d pilot plant has been built in Fano and tests are underway.

- Environmental impact of CWM product plant. Other aspects, such as disposal of water from beneficiation processes, coal storage and handling, waste water treatment have to be considered. Agip Carbone presented a CWM production plant project which foresees two coal streams at the exit of a beneficiation process. CWM is produced from the first stream which is beneficiated, while the stream enriched in ash and sulphur can be sold as a fuel for the cement industry and for fluidized bed boilers.

Transport

The advantages of transporting the CWM by pipeline compared with other transporation systems has been discussed. Ansaldo also presented an evaluation for the cleaning treatment of the waste-water after pipelining.

Combustion

AEM-Milan presented evaluations on the environmental impact of a power plant fully retrofitted to CWM, showing the benefits that can be achieved by using this fuel to replace residual oil.

The following aspects have been discussed:

- emission calculation
- waste water treatment
- ash disposal and delivery
- fuel supply

ENEL presented some results of the studies that have been carried out on combustion and on ESP compatibility. The advantages of NO_x emission reduction that can be achieved from burner design by lowering the flame temperature, through the presence of water and from the combustion process have been shown.

ENEL reported that the lower content of ash affects the ESP performance, which is different from pulverized coal. Some relatively large ash particles are present in the fly ash, due to the agglomeration phenomena occurring during combustion. These particles have a high carbon content that reduces the ash resistivity and affects ESP performance.

JAPAN

CWM Environment Activities, by T. Hanada

In Japan, energy alternatives are being actively developed since the oil crisis. The development of CWM began as part of this, but (Japan) we do not restrict CWM to solving the demerits of solid coal handling but envision them as a means for establishing a new coal chain which connects overseas coal mines and power plants in Japan.

CWM can prevent the spontaneous combustion and dust problems encountered with coals during storage. Combustion tests were conducted on CWM of different particle size distributions. Particularly, tests were conducted on the

characteristics of NO_x emission associated with combustion of CWM and how the air ratio affects the NO_x emission and unburnt carbon in ash from staged combustion. Coal cleaning tests were conducted on de-ashing of CWM. Also, conceptual designs were made of a CWM waste-water treatment system from the results of the coagulation tests.

THE NETHERLANDS

Summary on direct desulphurization research of CLM flames by, J.T. Krekels

In the early 80's when the Dutch government became convinced of the future potential applications of CLM fuel in industrial boilers, its first concern was the environmental aspect of this new commodity. The reason for this is obvious. The Netherlands is a gas country with sulphur-free natural gas. Power plants firing coal and oil will have to meet strict pollution standards. Also for industrial applications the present SO_2 standard is as low as 250 ppm (vol) in flue gas (equivalent to 0.4% sulphur in coal).

In 1984, when the Swartouv-Stevedoring Company and the Chemical Company Ankersmit provided facilites for CLM demo plants, it was arranged by the government that together with NEOM a research program should be executed to test the possibility of direct desulphurization in the CLM flame with calcium sorbents. This work was performed in 1986 at a cost of $300 000 by the IFRF at Ijmuiden.

The basic idea was that Ca-sorbent injection in special temperature zones of the furnace and/or in the bag filter area would be very costly for small-scale applications in industry or would require extensive boiler modifications. Therefore, only direct desulphurization in the flame with pre-mixed CLM Ca-sorbent slurries was deemed applicable. It was clear from the beginning that high desulphurization efficiencies were rather unlikely because of the peak temperatures in the flame. However, since importing of coal with higher than 1.2% S is not allowed in the country and whereas most coals used at this time have only 0.8% S, it was considered sufficient to obtain a 50% level of desulphurization.

Results obtained in the research program using 2.5 MWTh furnace and various CLM qualities (Ankersmit-Nycol), show only 30% desulphurization with $CaCO_3$. With $CaOH_2$ 50% desulphurization was obtainable but high slurry viscosities prohibited pumping. It was concluded that the direct desulphurization method will be applicable only with a special coal from this Exon-1-cerrejon (Colombia) mine.

This coal has only 0.45% S after washing and flotation and in direct firing with limestone, SO_2 in the flue gas of 0.3% S is considered viable. The mine production capacity will reach 14 Mt in the next few years and with a coal ash content of only 1% after flotation, the coal is considered ideal for CLM fuel application. The mine has been developed in recent years with $3 billion of Dutch development aid.

SWEDEN

Experiences of particulate emission control from commercial scale CWF combustion, by G. Linder

One of the major costs when converting an oil-designed boiler to CWF is the equipment for particulate removal in the flue gas. Efficient control of particulate matter in the flue gas is a prerequisite for making CWF environmentally acceptable. Despite this, very little has been reported to date on CWF combustion related to flue gas cleaning. There is reason to believe that fly ash from CWF combustion (at least in small to medium sized oil-designed boilers) has different characteristics from that of pulverized coal, i.e., particle size, carbon content, density and in general it is more benign. In Sweden, Fluidcarbon Intl. operates three boilers on commercial contracts, equipped with three different types of particulate removal systems.

In Lund a 21 MW CWF boiler was previously equipped with an off-line, jet pulse fabric filter designed for a gas flow of 20 000 m^3/h at 170° C, and a maximum particulate matter concentration of 5000 mg/nm^3. The total filter area was 220 m^3 distributed on 144 bags in four compartments. The overall performance was very good with cleaning efficiencies better than 99.8% at design load.

The filter was overloaded for long periods of time with flue gas flows about 40% above designed levels, without any noticeable problems and only a slight increase in pressure drop. The filter was also kept at ambient temperature for long periods during startup or shutdown, without any signs of sulphuric acid attack. The gas from the combustion of oil as well as from CWF passed through the filter.

Some of the bags were eventually damaged and had to be replaced. When the Lund boiler was completely converted to CWF in 1985, the filter capacity had to be increased and an electrostatic stone scrubber was installed. This is a fairly new technique in which the flue gases filter through a slow moving bed of small stones. The average size of the stones is 4-8 mm, and the particulate removal efficiency is enhanced by the electrical feed. The filter is designed for a flow of 60 000 m^3/h at 170°C and a voltage of 40 kV. Experience to date shows that cleaning efficiency is very sensitive to the gas flow, and at times difficulties arise in maintaining a stable voltage. The consumption of bed material seems to be too high, but can be decreased by lowering the circulation rate of the stone-material.

In Staffanstorp an on-line jet pulse fabric filter was tested with less satisfactory results. Experience has shown that when cleaning the bags in an on-line mode, they were never totally cleaned. This has led to an increased pressure drop causing a boiler shutdown. To avoid this problem the baghouse was exchanged for an off-line filter.

The conclusions are:

(1) Conventional off-line jet pulse fabric filters are suitable for CWF combustion fly ash emission

(2) The on-line fabric filter must be somewhat oversized to give a satisfactory performance.

(3) The dry electroscrubber needs further evaluation, but has the potential of being a very competitive flue gas cleaning technique for CWF.

U.S.A.

Transport of CWM by Barge - Environmental concerns and controls,
by Egon A. Kimel

Barges could provide an efficient and economical means for transporting CWM from producers to users. Cargo spillage is the greatest environmental concern.

Laboratory tests with six commercial highly loaded CWM fuels (70% coal, 1% additive) and one generic moderately loaded (55% coal) have shown a wide variation in settling behaviour, mainly affected by the chemical additive package used during preparation (Fig. 2). All slurries settled. To clean up CWM spills in shallow water-ways and at dockside, turbidity curtains that extend the full depth can be used (Fig. 7).

To reduce the number and severity of spills, the use of double skin barges and marine loading/unloading arms with pneumatic flush provision are recommended.

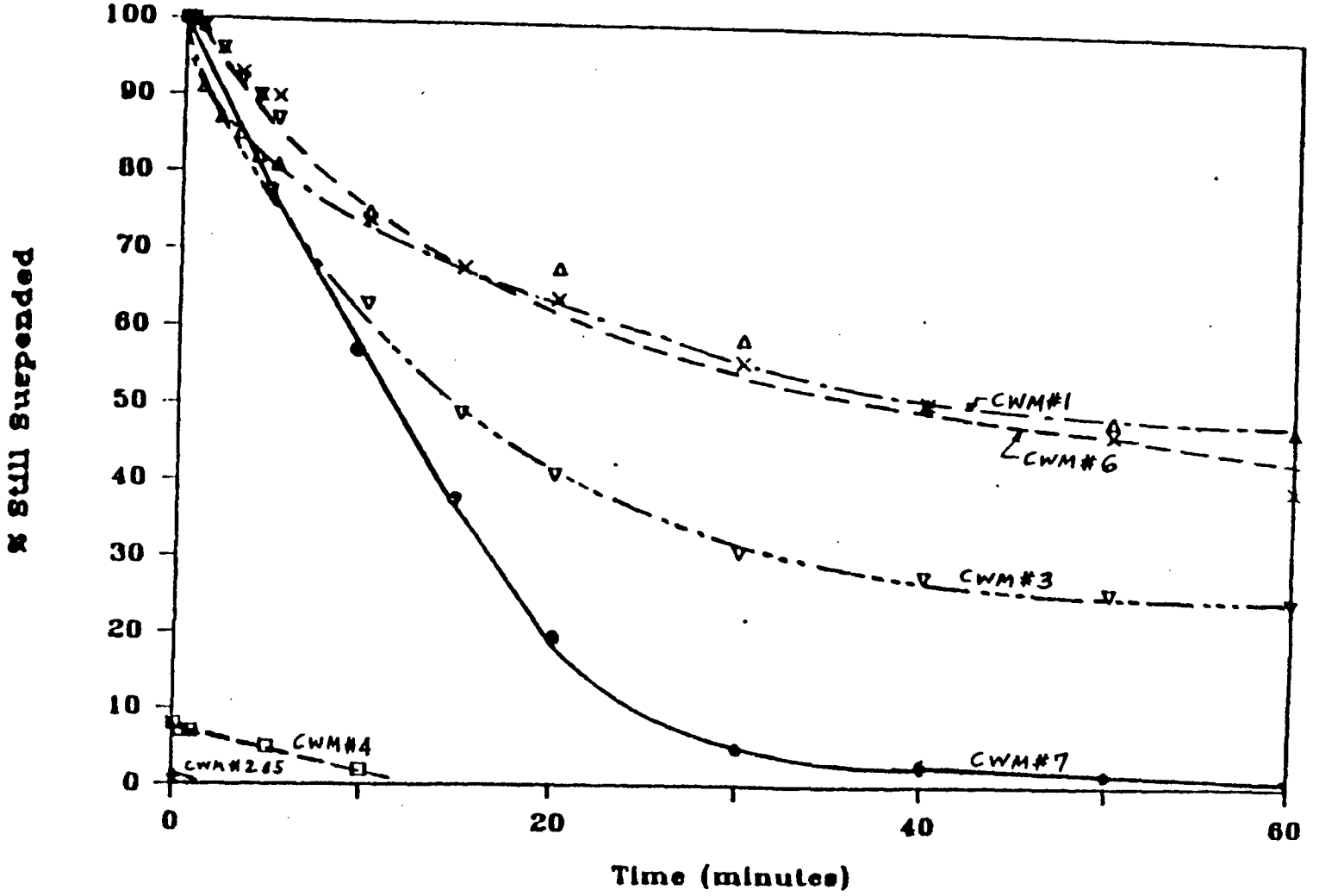

FIGURE 2

CWM SETTLING DATA
SURFACE-DROP RESULTS

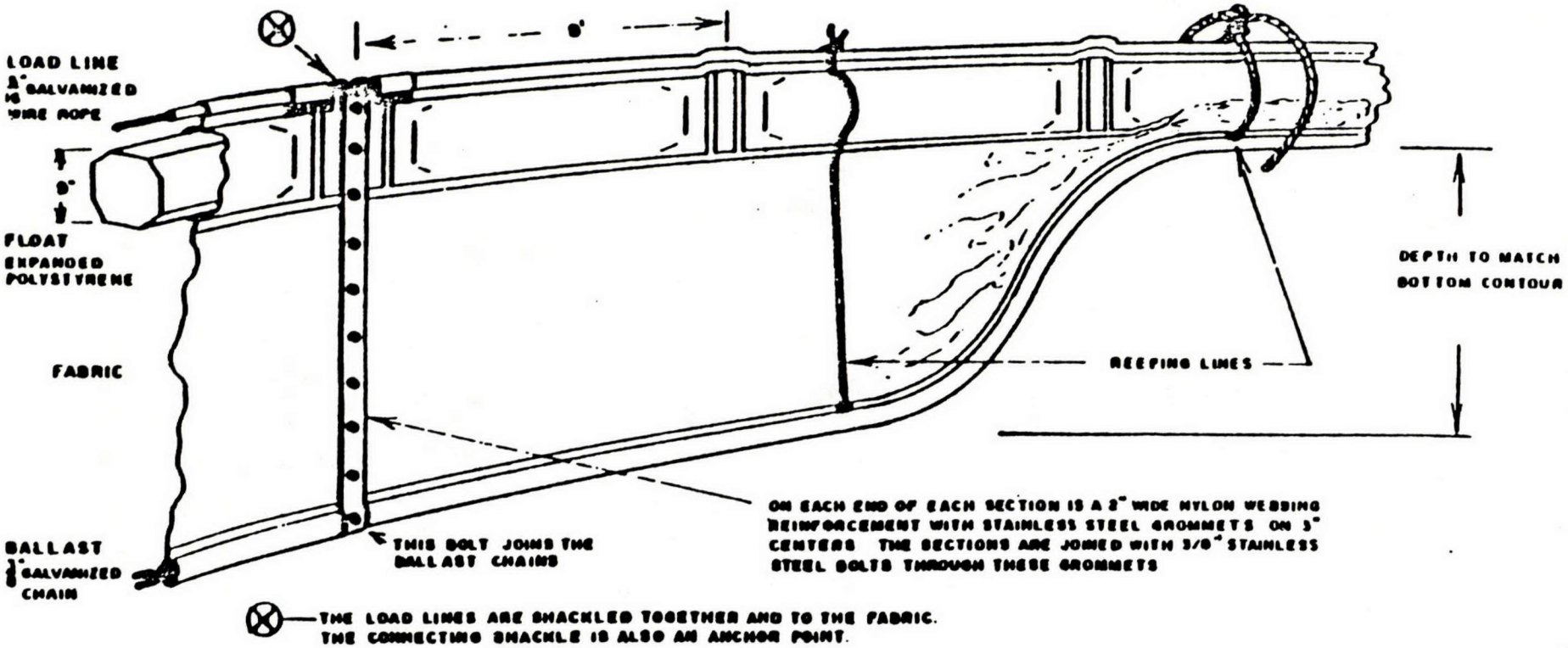

FIGURE 7

MOBILE CURTAIN CONTAINMENT

MAY 08, 1987 - SPECIAL TOPICS MEETING

0930h	AGIP CARBONE	SIMONI	Environmental benefits coming from CWM production and use
1000h	SWEDEN	LINDER	Experience of particulate emission control when firing CWF
1030h	AEM - MI	SPARACINO RICCI DI MARTINO	Environmental impact assessment of 74 MWe Cassano D'Adda power plant
1100h	C O F F E E B R E A K		
1115h	THE NETHERLANDS	KREKELS	Direct desulphurization of CLM flames by injection of calcium based-dry sorbents'
1145h	ENEL	CIONI BELLAGAMBA	Ash characterization in CWM combustion. ESP capability evaluations.
1215h	CANADA	WHALEY	Environmental aspects of the Canadian CWF Demonstration Program
1245h	L U N C H		
1415h	JAPAN 1	HANADA	NO_x characterization of CWM
1445h	USA	KIMEL	Environmental aspects of CLM transport
1515h	JAPAN 2	HANADA	Waste water treatment of CWM
1545h	ANSALDO	CLERICI DE PIETRI OGNIBENE POLLAROLO	CWM pipeline cleaning; optimization of the waste water treatment using thickener media
1615h	SPAIN	not present	
1645h	CSM	CORRERA MALGARINI	Use of CWM in iron making - environmental aspects