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SPACE SHUTTLE

Solid Rocket Motors
Thiokol Corporation

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SUMMARY OF JAYGO MIXING AND FSM-1 APPLICATION OF CASTABLE INHIBITOR AND LINER FINAL REPORT

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SUMMARY OF JAYGO MIXING AND FSM-1 APPLICATION OF CASTABLE INHIBITOR AND LINER

FINAL REPORT

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Thiokol CORPORATION
STRATEGIC OPERATIONS

SUMMARY OF JAYGO MIXING AND FSM-1 APPLICATION CASTABLE INHIBITOR AND LINER

(K. B. Evans)

INTRODUCTION

Two JAYGO planetary mixers (12- and 42-gallon) are being qualified to mix STW5-3224 liner and STW5-3223 castable inhibitor. These mixers are an integral part of a mix process which allows for safe addition of the asbestos component. An essential part of the engineering evaluation (ETP-0347) of these mixers is the generation of static test fire data. Ultimately, these results will help confirm the adequacy of these mixers for production mixing of liner and inhibitor. (These data are not required for qualification of the Certification Test Plan CTP-0125.) This report details the mixing, inhibiting, and sling-lining of JAYGO-mixed castable inhibitor and liner which were applied to the FSM-1 segments.

OBJECTIVE

To document processing events surrounding the JAYGO mixing of castable inhibitor and liner, and the subsequent inhibiting and sling lining onto the FSM-1 segments. Also, to substantiate the measured properties of these JAYGO-mixed materials (rheological and mechanical) and compare these properties to the existing production database.

SUMMARY

JAYGO-mixed castable inhibitor (large and small batches) was applied to the FSM-1 Forward, C/F, and C/A, segments. Jaygo-mixed liner was applied (hand and sling lining) to the FSM-1 C/F, C/A and AFT segments. A new mix procedure, which is essentially a reversal of the present production mix process with respect to sequence of material addition, was employed. JAYGO mixing also contrasts to present production mixing because of high shear dispersion, planetary mixing which includes a scraper blade, a wider mix temperature range, a higher polymer preheat temperature, vacuum mixing, a faster mixing speed, and a shorter overall mix cycle.

In general, the mixing of FSM-1 applied liner went smoothly. That is, all mix process requirements (end-of-mix temperature, end-of-mix viscosity, vacuum level, asbestos wetting time, mixing speed and times, dispersion speeds and times, material addition sequence, polymer preheat temperature and time) were met. Also, most sling and hand lining process requirements (sling liner flow rate, and time from end-of-mix to start of application and time from end-of-mix to end-of-application) were satisfied. However, each segment demonstrated significant pinholing which can probably be atttributed to a higher degree of sag control afforded by the Jagyo mixing process. Despite the pinholing, the coverage was considered to be complete because the observed pinholes had a visible layer of liner in the depression areas. Castable inhibitor mixing and application occurred without problems.

Review of the process verification witness panel data reveals that the average tensile adhesion and peel strengths of the JAYGO-mixed liner/insulation and liner/propellant bondlines were well within the RSRM segment production populations. In addition, process verification peel board values for these JAYGO-lined FSM-1 segments were typical of production segments. Hence, the conclusion that there were no bondline anomalies precipitated by the use of JAYGO-mixed liner on the FSM-1 segments and the propellant/liner/insulation bondlines in the JAYGO-lined segments are at least as reliable as the same bondlines in typical production segments.

The results of the tensile adhesion cup tests, which are part of standard inhibitor processing, verify that JAYGO-mixed castable inhibitor compares adequately to production inhibitor. That is, the average tensile strengths of specimens prepared from Jaygo-mixed inhibitor, which was applied to the FSM-1 segments, were well within production database confines. It is important to note that these specimens invariably fail in the propellant. Therefore, it is more accurate to conclude that the JAYGO-mixed inhibitor was at least as strong as the cohesive strength of the propellant. This conclusion is also typical of the normally processed inhibitor.

The potlife curves (viscosity vs time), which reflect the ease of application of the material, of the JAYGO-mixed, FSM-applied liner and inhibitor were relatively flat. This type of rheological behavior was exhibited during application by the spreadibility of the inhibitor and easily achieved high flow rates during sling lining. However, one exception occurred during the mixing of a 50-pound mix which was intended for the FSM-1 C/F segment. This mix was scrapped because the inhibitor viscosity increased at such a rate that the material became unworkable. However, a subsequent batch was mixed and successfully applied to the segment without incident.

As was previously mentioned, post-cure inspection of the sling lined segments showed significant pinholing. It is theorized that the thixotropy of the JAYGO-mixed liner is enhanced because the thixotropic agent (Thixcin "E") is incorporated at a higher mix temperature than normal. The enhanced thixotropy minimizes the slumpage during cure. Some slump is necessary in order to minimize pinholing. A thixotropic study will ensue that correlates mix temperature to slumpage. The outcome of this study may force a process change in the JAYGO mix procedure to lower the temperature at the point of Thixcin addition.

CONCLUSIONS

It is concluded that:

1. In terms of peel and tensile strengths, the propellant/JAYGO-mixed liner/insulation and propellant/JAYGO-mixed inhibitor bondlines in the FSM-1 segments are equivalent to the same bondlines in a regular production segment.

2. Generally, the mixing of liner and castable inhibitor in the JAYGO mixers occurred without incident.

CONCLUSIONS (cont'd)

3. For the most part, application of JAYGO-mixed castable inhibitor and liner transpired smoothly. However, the potlife of some batches was relatively short which stresses that the mix procedure has some inherent variability.

4. Sling lining of JAYGO-mixed liner resulted in an unusual amount of pinholing which can probably be attributed to the temperature at which the thixotropic agent was mixed. However, coverage was still deemed acceptable because a thin layer of liner was visible in the depressed areas of the pinholes.

RECOMMENDATIONS

It is recommended that:

1. Further characterization of the JAYGO mixing process be conducted to reduce the variability in the mixed material properties; namely, slump, end-of-mix viscosity, and potlife. This effort should include the following tasks:

   * Completion of the CTP tests to obtain aging and control bond data.

   * Further study of the effects of vacuum mixing on material properties; specifically, quantification and qualification of volatile matter, identification of minimum vacuum levels, verification of maximum vacuum level, necessity of mixer head purge, and a thorough comprehension of the HC polymer/asbestos reaction under vacuum.

   * Investigation of the relationship between mix temperature thixotropic properties, and the applied characteristics of Jaygo-mixed liner.

These studies will be helpful in further characterizing the Jaygo mix procedure so as to minimize material property variability.

DISCUSSION

In order to comply with OSHA regulations for airborne asbestos levels it is necessary to change the present production liner and inhibitor mix procedures to allow for safer addition of asbestos. A safe method of asbestos addition is to get it into the wet state as soon as possible. This method can be accomplished by prewetting the asbestos in the polymer in a booth which provides a barrier between the operator and materials. Prewetting the asbestos necessitates the JAYGO mixers which have the shearing capability to breakup asbestos agglomerates caused by the prewetting method.

DISCUSSION (cont'd)

The regular production and JAYGO mix procedures for large and small castable inhibitor and liner batches are contrasted in Figure 1. Present liner and castable inhibitor mixing are accomplished in the Troy Angular (batches of 100 pounds or greater) and the Readco (batches of less than 100 pounds) mixers. These mixers and the JAYGO mixers are illustrated in Figures 2, 3, and 4. Essentially, the JAYGO mix procedure is a reversal of the present production mix procedure in terms of sequence of material addition. Other differences between JAYGO and regular production mixing which are of significance include:

* Higher polymer preheat temperature
* High shear incorporation of powders and fibers
* Vacuum mixing
* Shorter overall mixing time
* Faster blade mixing speed

The JAYGO mix procedure was developed as a result of testing outlined in the Engineering Test Plan (ETP-0347).

Although the Certification Test Plan (CTP-0125) does not make static test fire data a prerequisite to qualification of the mixers for production mixing, the Liner Program Team considers these data valuable in ultimately gaining stamp of approval for the use of these mixers. Therefore, the goal was set to sling line and inhibit at least one FSM-1 segment with JAYGO-mixed materials. As listed below the following segments were sling lined and inhibited:

FSM-1 Segment	Material Mixed and Applied
Forward	* Two 180-pound batches of inhibitor
C/F	* One 50-pound batch of inhibitor * Two 185-pound batches of liner (sling lined) * One 40-pound batch of liner (hand lined)
C/A	* One 50-pound batch of inhibitor * Two 185-pound batches of liner (sling lined) * One 40-pound batch of liner (hand lined)
Aft	* Two 200-pound batches of liner (sling lined) * One 40-pound batch of liner (hand lined)

Review of JAYGO Mixing and Subsequent Application

Generally, the mixing and application of the above listed batches of inhibitor or liner went smoothly. The ensuing paragraph discusses a feature of the JAYGO mix procedure which was of concern but was successfully verified by FSM-1 liner and inhibitor processing:

Mix Temperature: The basis for the required end-of-mix temperature range of 150° to 165°F is activation of the thixotropic agent. (This activation behavior is explained in detail later.) The primary factors which regulate mix temperature are water jacket temperature and polymer preheat temperature. As indicated in Figure 1, the JAYGO mix procedure allows for water jacket temperature adjustment during mixing to stay within this temperature range. Ordinarily an adjustment to the water jacket temperature was not necessary. However, when an adjustment was made the mix temperature was controlled enough to fall within the targeted end-of-mix temperature range. Of vital importance is the fact that the mix process temperature requirements for polymer preheat and water jacket temperature have been set so that the end-of-mix temperature will consistently fall within this range which will provide good thixotropy in the liner.

The following paragraphs detail some of the problems that were encountered.

Asbestos and Thixcin Wetting: This step is difficult because it takes a certain amount of technique for the operator to meet opposing objectives. First, the asbestos must be wetted as quickly as possible to minimize personnel exposure and preclude the asbestos/polymer reaction. Second, the amount of air incorporated into the asbestos/polymer slurry must be minimized. Quick asbestos wetting forces operation of the mechanical mixer at a faster speed which increases the volume of air introduced into the mix. Conversely, operation of the mechanical mixer at a slow speed decreases air introduction and increases wetting time. From an operators standpoint this step is vague and must be improved to eliminate operator judgement during the operation of the mix cycle.

Pulling Dependable Vacuum: The small JAYGO mixer was incapable of holding consistent vacuum. Although the post Mapo/ERL and Iron Octoate addition minimum vacuum requirement of 1.5 inches of Hg was repeatedly satisfied; frequently, the mixer was unable to hold this level upon start up of the mixer and dispersion blades. The relationship between the vacuum levels and potlife needs to be more precisely defined to more completely understand the importance of vacuum levels to this mix cycle. In the meantime, the mixer is being repaired to seal better and maintain vacuum levels.

Low End-of-Mix Temperature Liner: A 40-pound liner mix which was intended for the FSM-1 Aft segment was scrapped because of a low end-of-mix temperature (147°F). The low temperature occurred because hot water was not flowing sufficiently through the jacket. The problem, which was caused by a closed valve which inhibited flow to the jacket, was corrected. Shortly thereafter a mix was successfully made and applied to the segment.

Short Potlife: A 50-pound inhibitor mix which was intended for the FSM-1 C/F segment was scrapped because of a short potlife (steep slope in the viscosity vs time curve). The viscosity of the inhibitor increased so fast that it became difficult to spread. It is suspected that the short potlife was caused by an extraordinary amount of air incorporation into the asbestos/polymer slurry and compounded by the inadequate vacuum levels during mixing. A subsequent mix, which used the same raw materials, was successfully made and applied to the segment during the following shift. The success and failure of two mixes of identical raw materials stress that there is some intrinsic variability in the mix procedure.

Pinholes: Upon completion of precure of the liner the segments were inspected for slump, coverage, and pinholes. Normally it is desirable for the liner layer to slump slightly in order to cover pinholes which form during sling lining. There was very little slump in the FSM-1 C/F, C/A, and Aft segments. Consequently, these segments manifested significant pinholing; particularly, the Aft segment. In more descriptive terms, these pinholes were more numerous and larger than normal. However, there was a liner film layer at the bottom of each pinhole; hence, coverage on each segment was complete. The concern toward the pinholing problem is reduced when the results of ETP-0612 are taken into consideration. Basically, these results show that liner voids up to 0.5 inch in diameter do not significantly effect propellant/liner/insulation bond strengths.

Without further research into the thixotropic behavior of JAYGO-mixed liner, it can only be postulated that the extremely low amount of slump and resultant pinholing was caused by more efficient activation of the thixotropic agent. In rheological terminology, thixotropic activation is defined as processing the thixotropic agent to the point that a balance is achieved between minimum slumpage or sag and minimum processing viscosity. Temperature and shear rate are two processing variables which govern Thixcin "E" activation. The vendor recommended temperature range for Thixcin activation is 150° to 170°F. At temperatures below 150°F the Thixcin will not become deagglomerated, thixotropic chains will not form, and the material wills slump. Temperatures above 170°F approach the melting point of Thixcin (18°F) and rheological activity is lost by partial liquifecation of the Thixcin. During production mixing the Thixcin is never exposed to temperatures greater than 160°F. Alternatively, during JAYGO mixing the Thixcin is exposed to temperatures as high as 169°F. Higher JAYGO mix temperature exposure probably activates the Thixcin to rapidly form a greater number of thixotropic chains. The activation is even more enhanced by the shear effects of the dispersion blade.

Some general observations about the application of the materials:

Inhibitor: Operators who were involved with the application of the inhibitor gave mixed opinions about spreadibility of the JAYGO-mixed inhibitor. These opinions ranged from easier to apply than regular production to more difficult apply.

Liner: Subjectively speaking, the JAYGO-mixed liner was easier to sling line than regular production liner. This judgment is primarily based upon the fact that the higher sling liner flow rates were quickly reached and maintained. Exceptions to this observation are the two mixes sling lined onto the C/A segment. The higher sling liner flow rates were not as easily reached, which is not surprising because the potlife of these two mixes was short compared to the other mixes.

Review of the Measured Properties of the JAYGO-Mixed Materials

A full characterization of the mechanical, rheological, and physical properties of JAYGO-mixed liner and inhibitor will be performed when the Certification Test Plan is executed. However, some mechanical and rheological properties of the JAYGO-mixed, FSM-1 applied liner and inhibitor were measured and are summarized as follows:

Process Verification Witness Panel Data: Table I tabulates the average tensile adhesion and peel strength data generated from witness panels of the corresponding RSRM or FSM-1 segments. Data from recently processed RSRM segments are included simply for comparison purposes. Investigation of the data shows that the witness panel mechanical properties of the JAYGO-lined segments are well within the population database. The parameters of greatest interest are Rat T and Rat P which are a ratio of the average tensile adhesion or peel strength to the respective lower control limit. These values signal that the process is out of control in terms of bond strength (Rat T or Rat P < 1). Obviously, the JAYGO-lined segments, as well as regular production segments satisfy this statistical process control limit for the liner/insulation and liner/propellant bondlines.

Peel Board Data: Table II summarizes the peel board data generated as a result of normal processing of the designated segment. Again, the data which correspond to the JAYGO-lined FSM-1 segments are within the production database. It is important to note that these data are essentially a measure of the cohesive strength of the propellant since failure invariably occurs in the propellant. Therefore, the data are trivial in terms of quantifying the mechanical strength of the liner. Nevertheless, the data verify the JAYGO-mixed liner was comparable to production liner.

Tensile Adhesion Cup Data: Table III enumerates the results of the tensile adhesion cup tests which are performed in conjunction with normal production inhibiting of each segment. The JAYGO-mixed inhibitor yielded adequate material. That is, the JAYGO-mixed inhibitor bonded to the propellant equally as well as regular production inhibitor. Invariably these specimens fail in the propellant; thus, the data reflect the cohesive strength of the propellant.

Rheological Data: Figures 5 through 9 detail the viscosity vs time curves for the large and small inhibitor and liner JAYGO mixes. Included in these figures are the curves of numerous JAYGO test mixes made as part of engineering tests and some mixes made in production mixers by the regular mix cycle. In addition, end-of-mix viscosities and temperature of all these mixes are provided in these figures. Although viscosity vs time is not a pure measurement of potlife, it provides an idea as to how quickly the material is curing. Also, it is reliable in monitoring the time at which the liner and inhibitor become difficult to apply.

Generally, JAYGO-mixed, FSM-1 applied inhibitor and liner demonstrated viscosity vs time curves similar to previous production type and JAYGO mixes. The noticeable exception is the previously mentioned 50-pound inhibitor mix which was deemed unspreadable and scrapped. This curve (Figure 9) confirms that the viscosity rise rate was out of control. As was previously hypothesized, the likely cause was a combination of the incorporation of an excess amount of air during asbestos prewetting and lack of consistency in pulling vacuum. This theory is supported by discussions with mix room personnel and previous tests which demonstrated that air accelerates the yet to be defined chemistry between the polymer and asbestos.

This mix also emphasizes that there are some nebulous aspects of the JAYGO mix procedure which have direct effect on the potlife and which need to be more clearly defined for the operator. Unfortunately, a viscosity vs time curve of the ensuing mix which was successfully applied was not generated and is not available for comparison. Only the end-of-mix viscosities provide comparison and it is noteworthy that the follow up mix had an end-of-mix viscosity of one-half the scrapped mix.

In Figures 5 and 6 the curves of the liner batches which were applied to the FSM-1 C/A segments exhibited steeper slopes than the other JAYGO-mixed, FSM-1 applied mixes. These curves could be considered borderline in terms of potlife acceptability for sling lining. (A curve for one of the 200-pound batches sling lined onto the Aft segment was not generated.) These slopes were manifested during C/A sling lining as it was more difficult to achieve the higher flow rates than it was during Aft and C/F sling lining. Presumably, the reason for the higher slope was due to the bag of asbestos (Bag No. 24 of Lot No. 0021) which may have been somewhat higher in volatiles than the other bags. Apparently, the vacuum levels were not sufficient enough to overcome the effect of volatiles on the polymer/asbestos reaction. This fact leads to the conclusion that vacuum mixing levels must be more completely understood to effectively control the potlife of JAYGO-mixed liner and inhibitor.

TABLE 1

PROCESS VERIFICATION WITNESS PANEL DATA

SEGMENT	* BONDLINE	TENSILE ADHESION STRENGTH (psi)	+ RAT T	PEEL STRENGTH (pli)	@ RAT P
FSM-1 A	IE	204	1.55	29	2.23
FSM-1 C/F	IE	160	1.21	28	2.15
FSM-1 F	IE	173	1.31	25	1.92
FSM-1 C/A	IE	N/A	N/A	N/A	N/A
15 A C/A	IE	212	1.61	31	2.38
15 A F	IE	154	1.17	27	2.08
14 B C/F	IE	171	1.30	23	1.77
14 A C/A	IE	158	1.20	24	1.85
14 A C/F	IE	168	1.27	24	1.85
14 B F	IE	165	1.25	25	1.92
15 A A	IE	172	1.30	24	1.85
13 A C/F	IE	196	1.48	25	1.92
13 B C/A	IE	196	1.48	24	1.85
13 B C/F	IE	191	1.45	27	2.08
14 A A	IE	212	1.61	26	2.00
14 A F	IE	177	1.34	27	2.08
14 B A	IE	156	1.18	25	1.92
FSM-1 A	IF	201	1.72	28	1.65
FSM-1 C/F	IF	186	1.59	31	1.82
FSM-1 F	IF	194	1.66	23	1.35
FSM-1 C/A	IF	203	1.74	34	2.00
14 A A	IF	200	1.71	32	1.88
14 B C/A	IF	172	1.47	26	1.53
15 A C/A	IF	209	1.79	31	1.82
15 B A	IF	137	1.17	25	1.47
13 B A	IF	250	2.14	21	1.24
13 A C/A	IF	199	1.70	24	1.41
13 B C/F	IF	180	1.54	28	1.65
14 A C/A	IF	166	1.42	25	1.47
14 A C/F	IF	166	1.42	26	1.53
14 A F	IF	182	1.56	27	1.59
14 B A	IF	156	1.33	27	1.59
15 A A	IF	163	1.39	27	1.59
12 A C/F	IF	180	1.54	22	1.29
12 A F	IF	149	1.27	24	1.41
12 B A	IF	179	1.53	27	1.59
12 B C/F	IF	174	1.49	26	1.53
13 A C/A	IF	159	1.36	29	1.71
13 B F	IF	173	1.48	27	1.59
FSM-1 A	IG	122	1.37	10	2.00
FSM-1 C/A	IG	127	1.43	10	2.00
FSM-1 C/F	IG	124	1.39	10	2.00
FSM-1 F	IG	129	1.45	9	1.80
15 A C/A	IG	125	1.40	9	1.80
15 A F	IG	116	1.30	7	1.40
14 B C/A	IG	113	1.27	9	1.80
14 B C/F	IG	112	1.26	7	1.40
13 A C/F	IG	130	1.46	8	1.60
13 B C/A	IG	114	1.28	8	1.60
13 B C/F	IG	121	1.36	9	1.80
14 A A	IG	124	1.39	7	1.40

* I E = LINER/INSULATION BONDLINE EXPOSED TO LINER PRECURE. ALL FAILURE OCCURRED COHESIVELY IN THE LINER
I F = LINER/INSULATION BONDLINE EXPOSED TO PROPELLANT CURE CYCLE. ALL FAILURE OCCURRED COHESIVELY IN THE LINER.
I G = LINER/PROPELLANT BONDLINE. ALL FAILURE OCCURRED COHESIVELY IN THE PROPELLANT

+ RAT T = TENSILE ADHESION STRENGTH / LOWER TENSILE CONTROL LIMIT.

@ RAT P = PEEL STRENGTH / LOWER PEEL CONTROL LIMIT.

TABLE 2

PEEL BOARD VALUES

SEGMENT	* AVERAGE PEEL STRENGTH (pli)
FSM-1 A	8.7, 9.2, 9.0, 8.1, 8.7.
FSM-1 C/F	7.7, 8.0, 8.7, 8.7, 8.5
FSM-1 C/A	8.2, 8.8, 8.5, 8.5, 8.8
15 A F	8.9, 7.6, 4.8, 8.4, 5.5
14 A A	8.5, 8.6, 7.5, 8.3, 7.8,
14 B C/A	8.4, 8.7, 7.8, 8.5, 8.2
14 B C/F	9.0, 8.8, 8.8, 8.7, 7.4
15 B A	8.2, 9.3, 8.9, 7.7, 8.3
14 B A	8.8, 8.6, 6.1, 8.4, 7.6
14 B F	6.1, 7.8, 8.6, 8.1, 7.8

* EACH PEEL VALUE REPRESENTS THE AVERAGE OF FIVE SPECIMENS. THERE ARE 25 SPECIMENS TESTED PER SEGMENT (10 PER 185 OR 200 POUND MIX AND 5 PER 40 POUND MIX).

ALL FAILURE OCCURRED COHESIVELY IN THE PROPELLANT

VALUES FOR FSM-1 F WERE NOT AVAILABLE

TABLE 3

TENSILE ADHESION CUP RESULTS

SEGMENT	* AVERAGE TENSILE STRENGTH (psi)	CV %
FSM-1 C/A	139	6.2
FSM-1 F	137	3.2
	136	5.9
FSM-1 C/F	131	4.0
	131 (SCRAPPED)	6.5
14 B C/A	122	3.7
14 A F	111	1.6
	114	2.3
	111	4.7
14 B C/F	114	6.5
13 A C/A	160	1.7
15 A C/A	128	2.8
15 A F	128	5.1
	123	5.0
	134	6.9

* AVERAGE OF THREE VALUES

NOTE: ALL FAILURE OCCURRED IN THE PROPELLANT

FIGURE 1 COMPARISON OF MIX PROCESSES

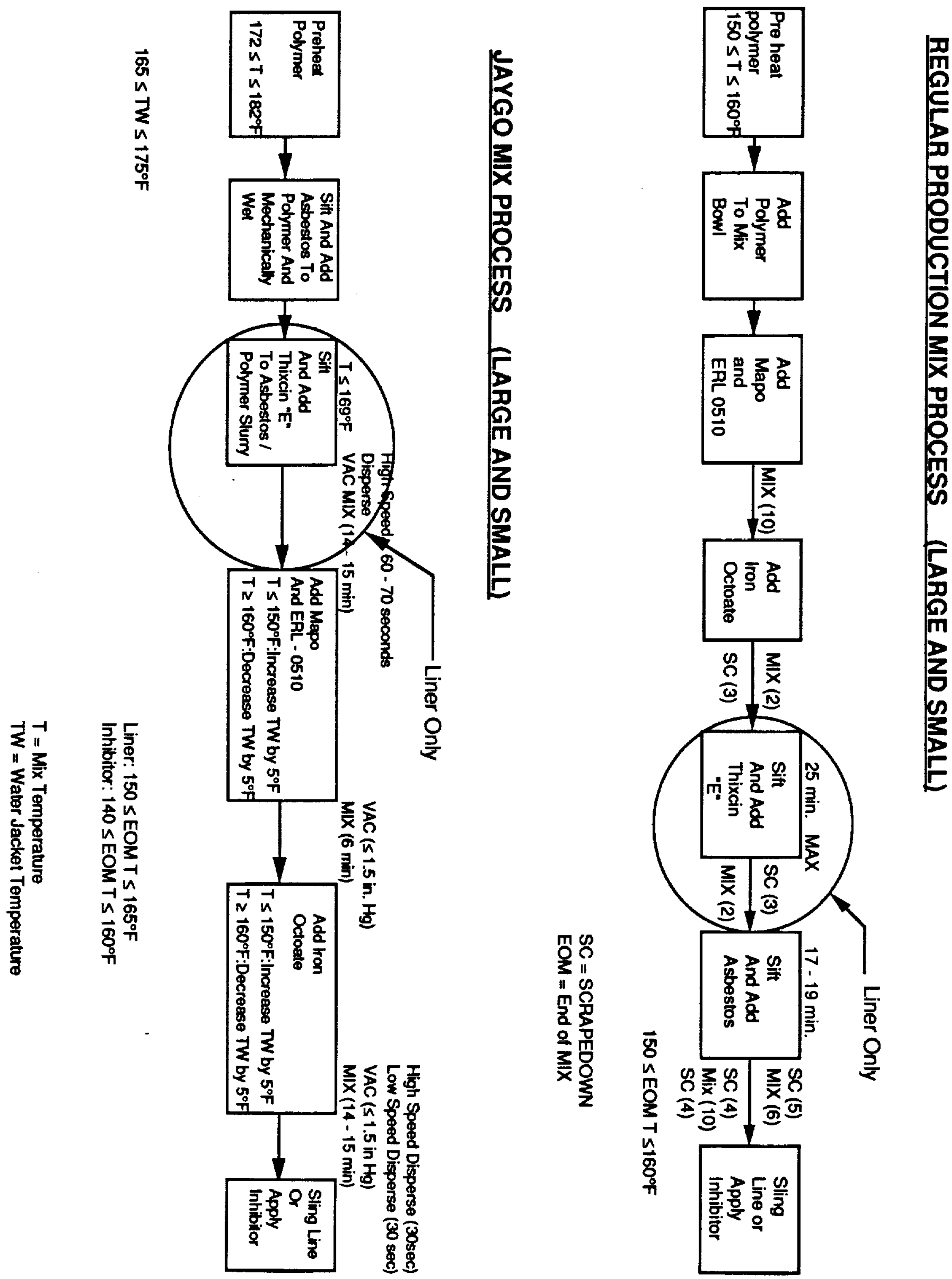


FIGURE 2

READCO MIXER

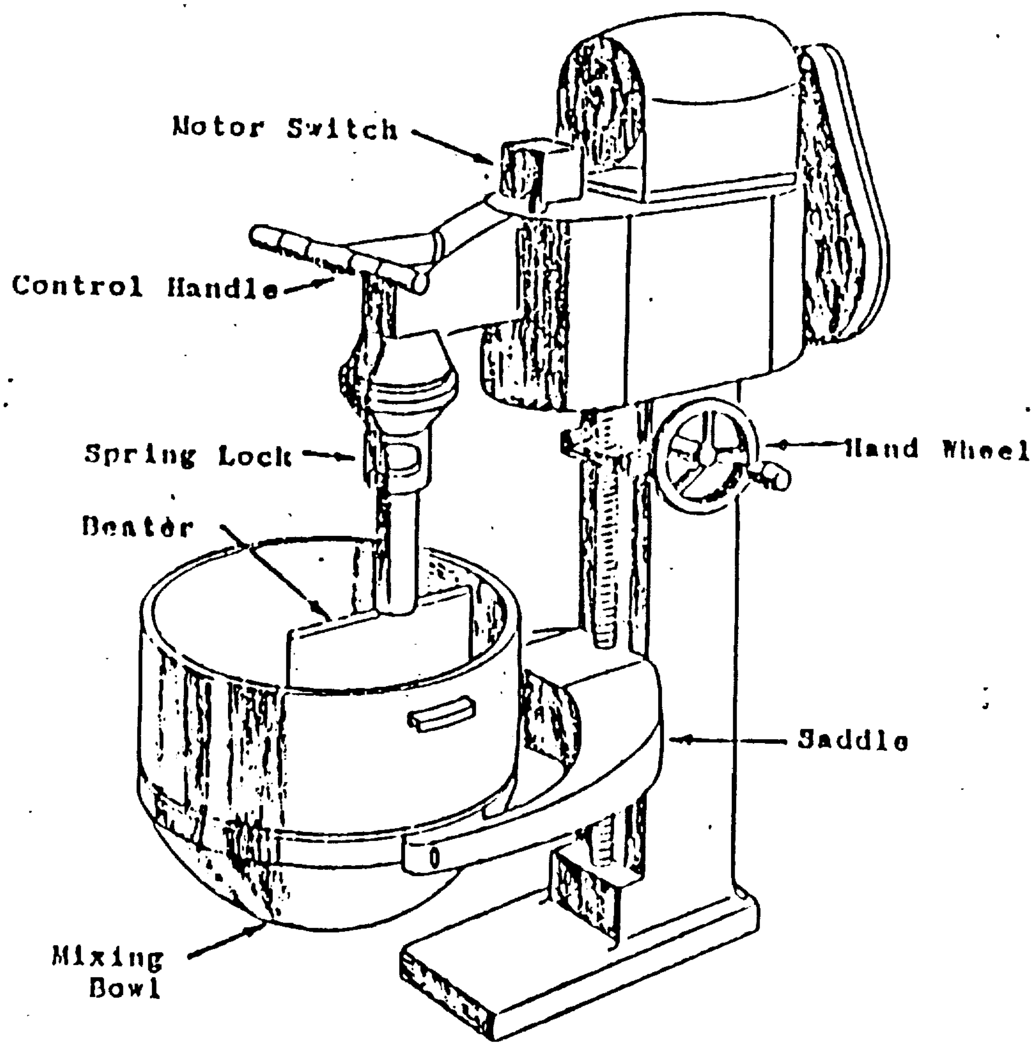
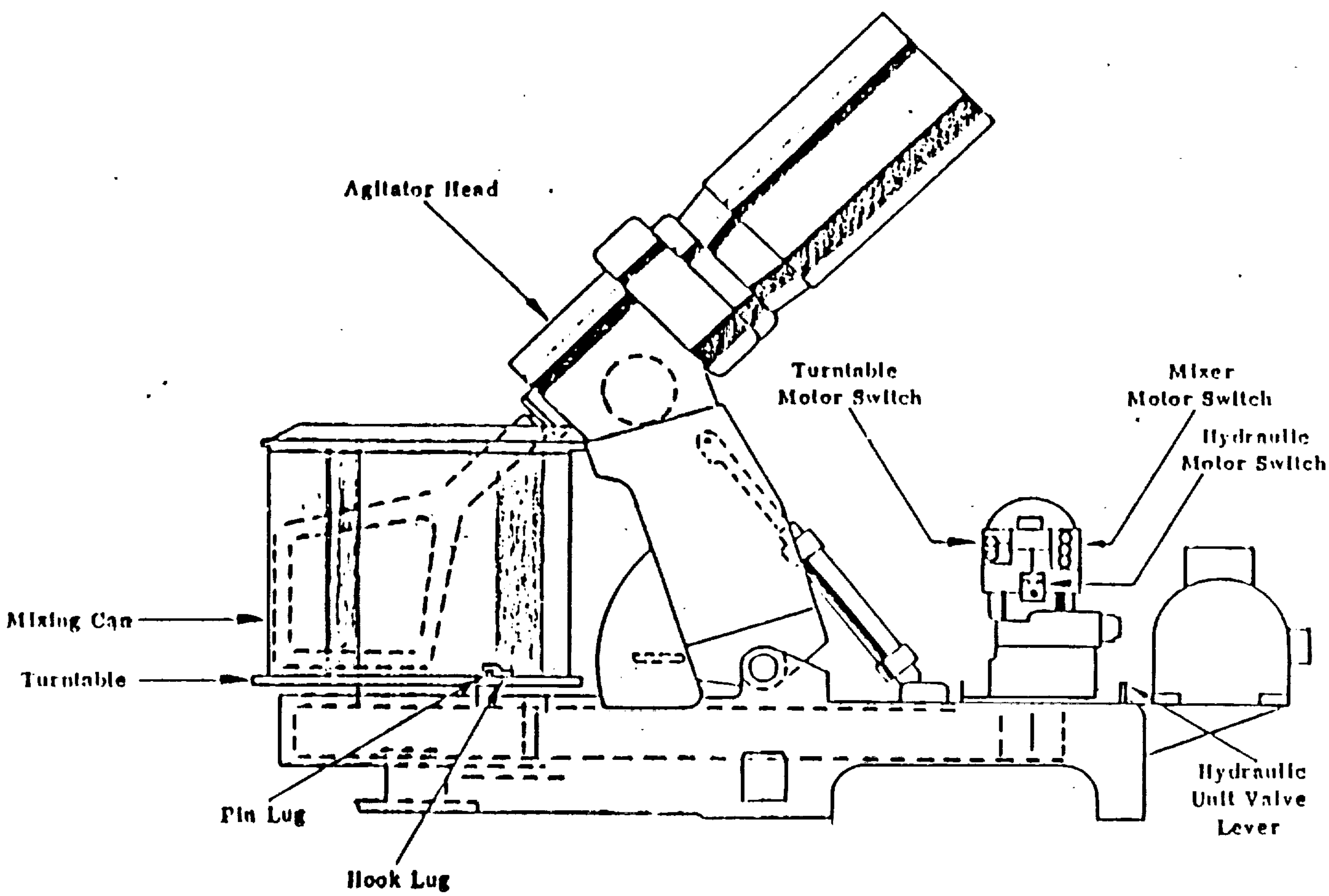


FIGURE 3

TROY ANGULAR MIXER



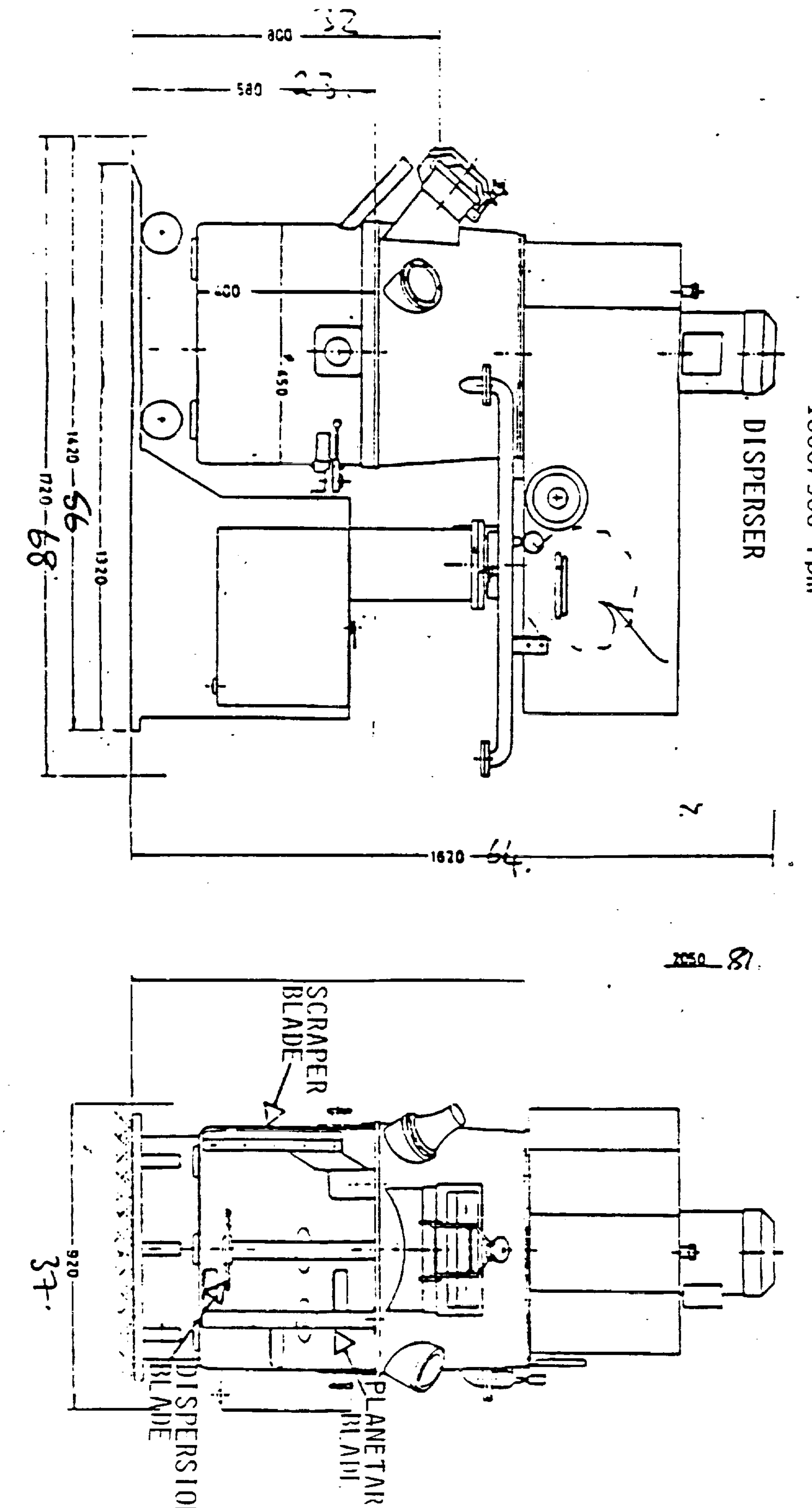
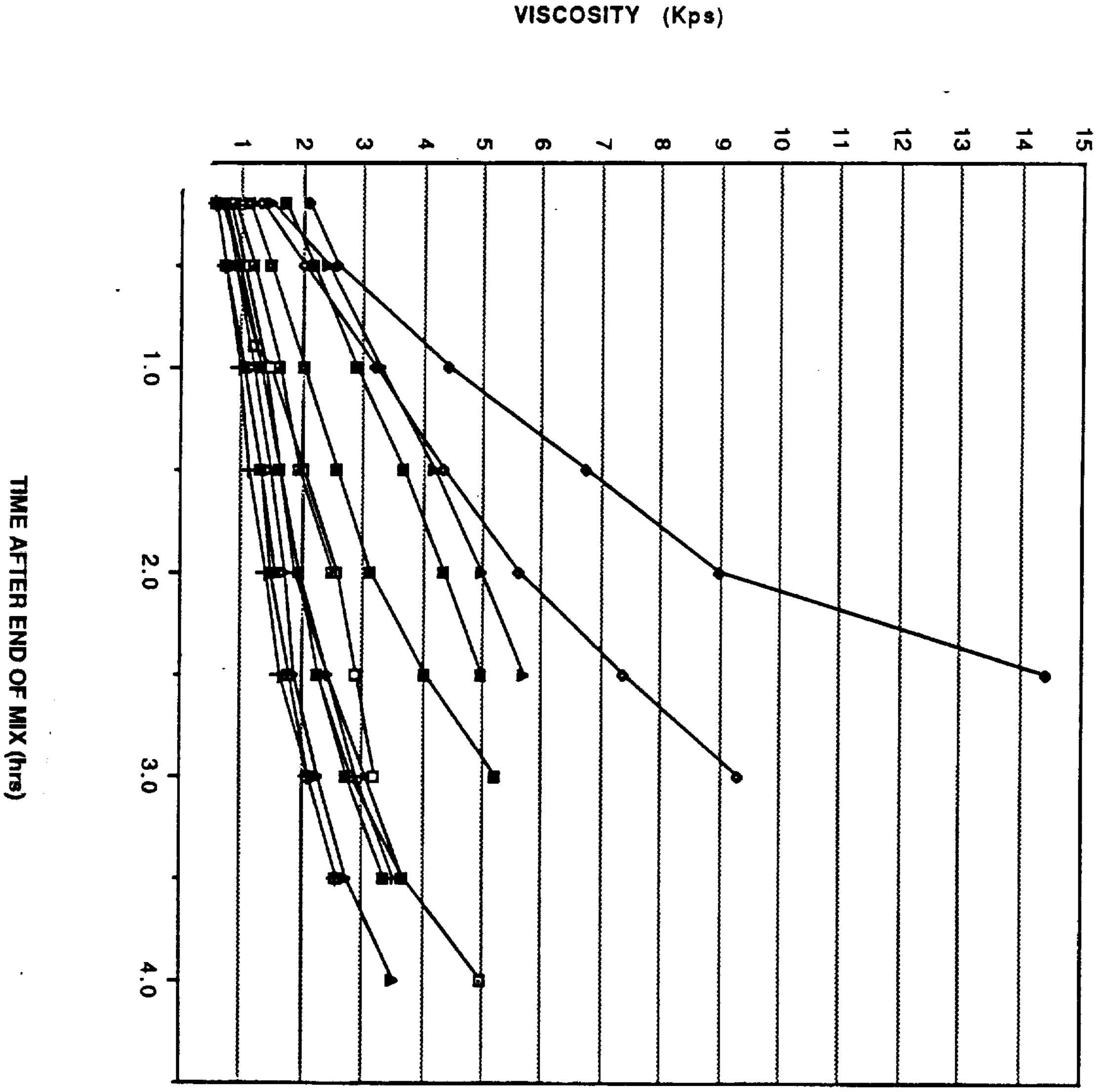


FIGURE 4 -- JAYGO MIXER

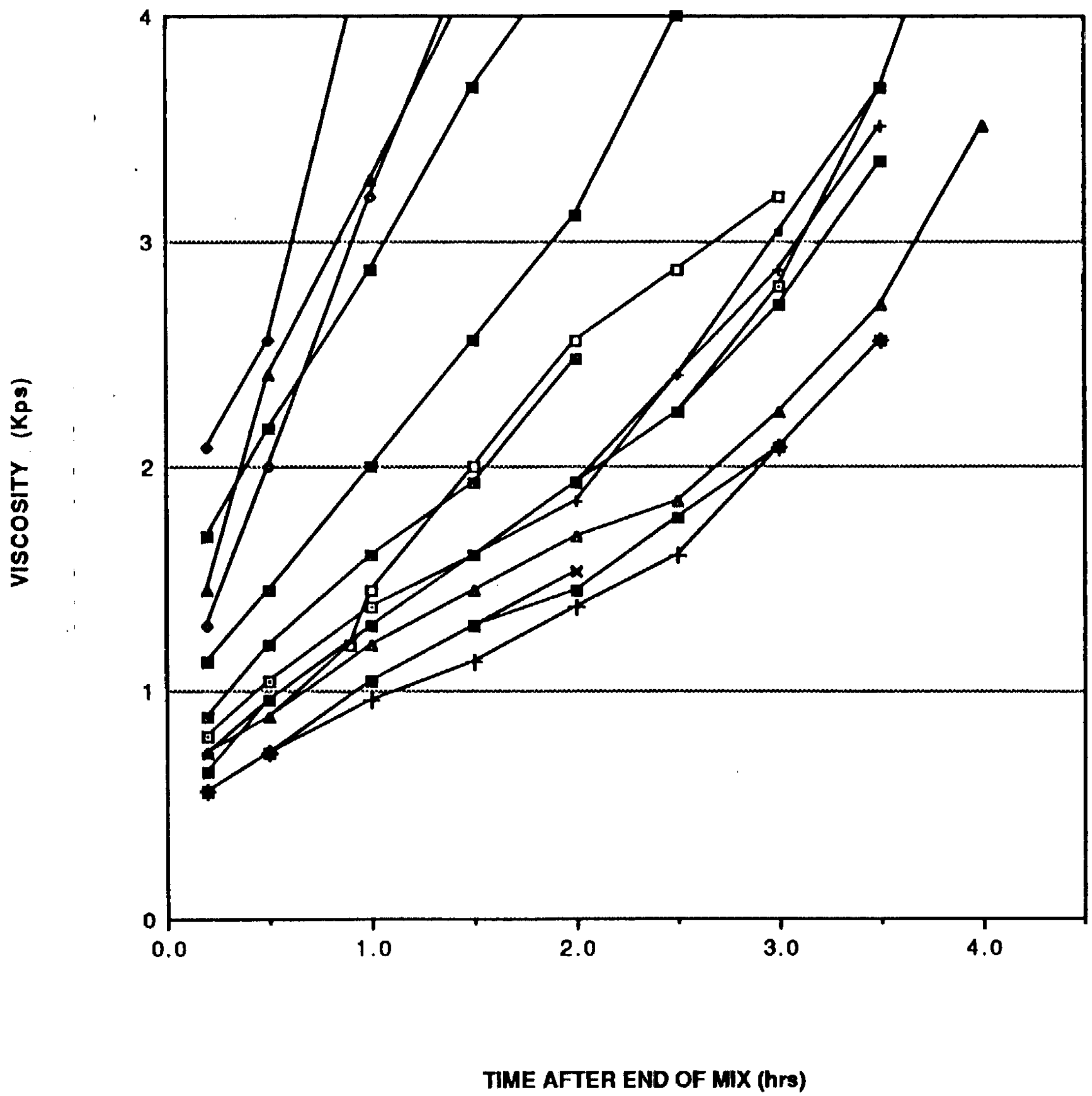
FIGURE 5
JAYGO 200 & 185-LB LINER MIXES



	MIX NO.	EOM VISC (poise)	EOM TEMP (F)
JAYGO 1-A	307155	563	164
JAYGO 2-A	307154	941	164
JAYGO 3-A	307153	902	167
JAYGO 4-A	310550	1341	165
JAYGO 5-A	310023	425	159
TROY 1	307285	N/A	155
JAYGO 6-A	310022	N/A	156
LPS-1	310288	630	162
LPS-2	310287	669	164
LPS-3	310289	643	162
FSMA	310314	570	164
FSM C/F-1	310189	499	158
FSM C/F-2	310281	502	161
FSM C/A-1	310712	861	161
FSM C/A-2	310713	678	162
FSMA	309990	512	164

NOTE: No curve was generated for FSMA Mix No. 309990

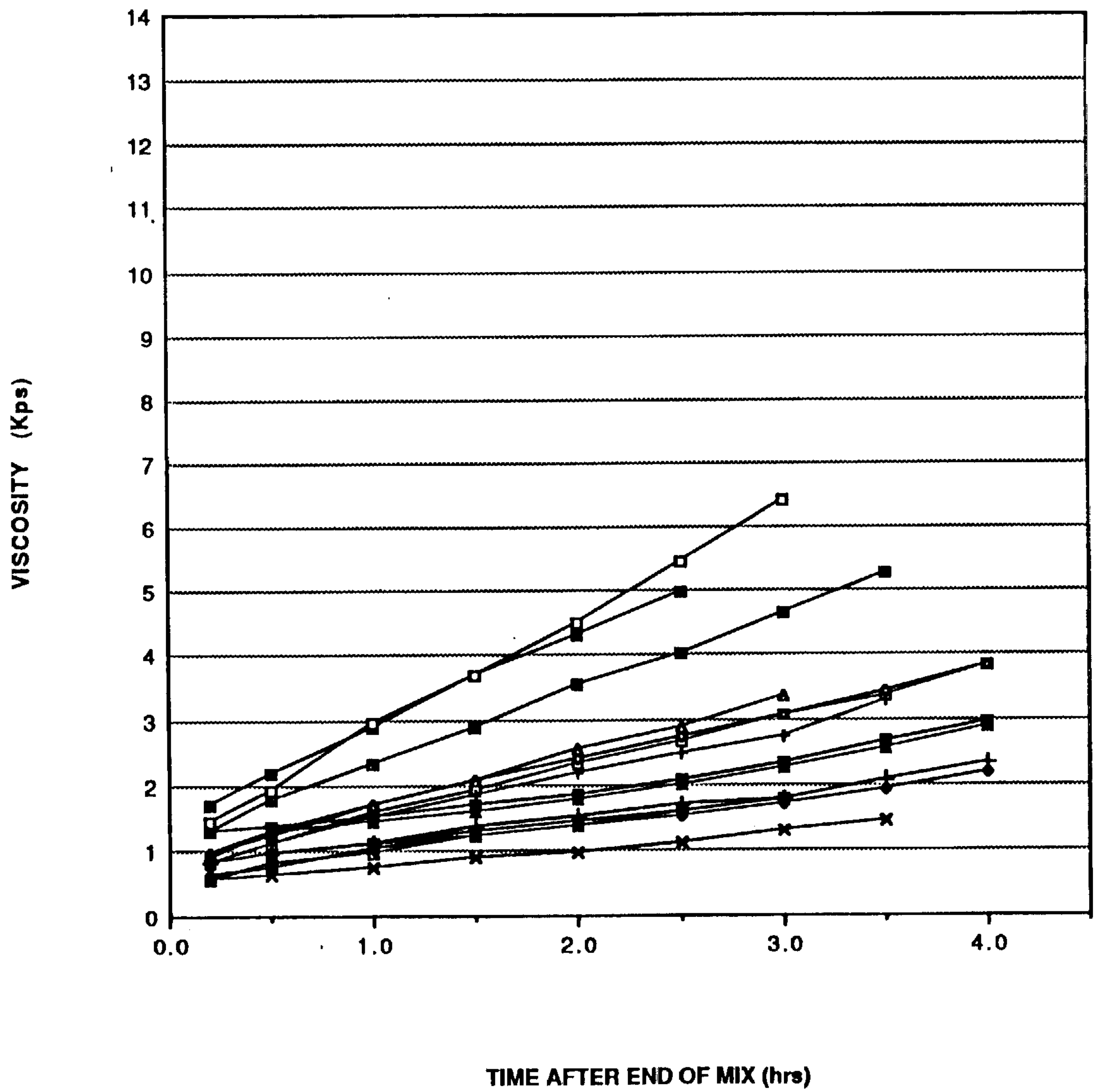
FIGURE 6
JAYGO 200 & 185-LB LINER MIXES
(LOWER LEFT - HAND CORNER OF FIGURE 5)



	MIX NO.	EOM VISC (poise)	EOM TEMP (F)
JAYGO 1-A	307155	563	164
JAYGO 2-A	307154	941	164
JAYGO 3-A	307153	902	167
JAYGO 4-A	310550	1341	165
JAYGO 5-A	310023	425	159
TROY 1	307285	N/A	155
JAYGO 6-A	310022	N/A	156
LPS-1	310288	630	162
LPS-2	310287	669	164
LPS-3	310289	643	162
FSMA	310314	570	164
FSM C/F-1	310189	499	158
FSM C/F-2	310281	502	161
FSM C/A-1	310712	861	161
FSM C/A-2	310713	678	162
FSMA	309990	512	164

NOTE: No curve was generated for FSMA Mix No. 309990

FIGURE 7
JAYGO 180-LB INHIBITOR MIXES



	MIX NO.	EOM VISC (poise)	EOM TEMP (F)
MIX I 1A	310682	1177	162
MIX I 2A	310112	675	156
MIX I 3A	310017	640	156
MIX I 4A	--	--	--
MIX I 5A	310115	1620	158
MIX I 6A	* CPI	N/A	N/A
MIX I 7A	310079	793	159
MIX I 8A	310080	900	163
TROY I	* CPI	N/A	N/A
MIX I 9A		826	162
MIX I 10A	310207	1386	146
I PS-1	310199	512	155
I PS-2	31020	736	156
FSMF-1	310221	573	160
FSMF-2	310222	592	159

* MIXES MADE AS PART OF ATTEMPT AT CTP

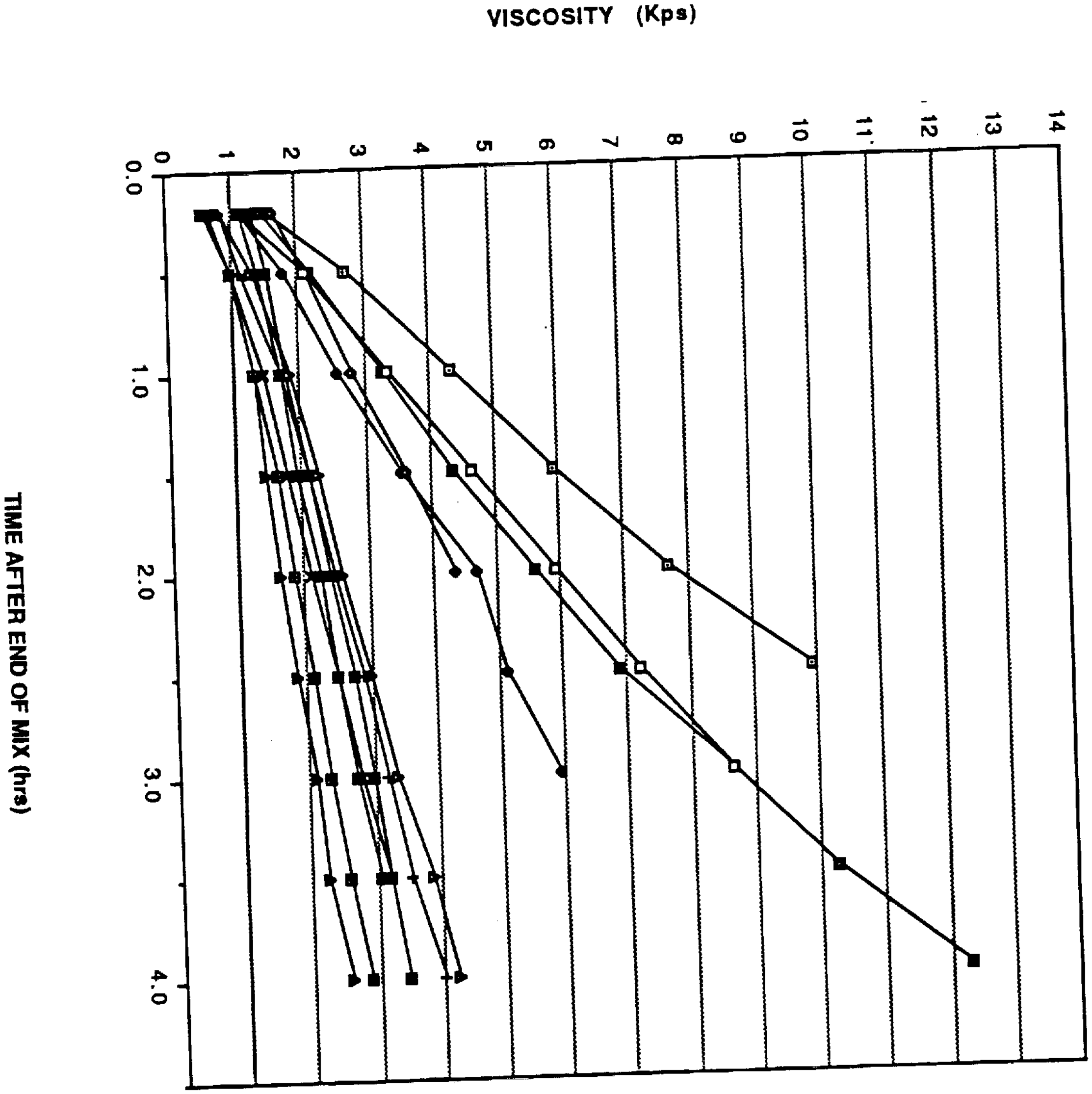


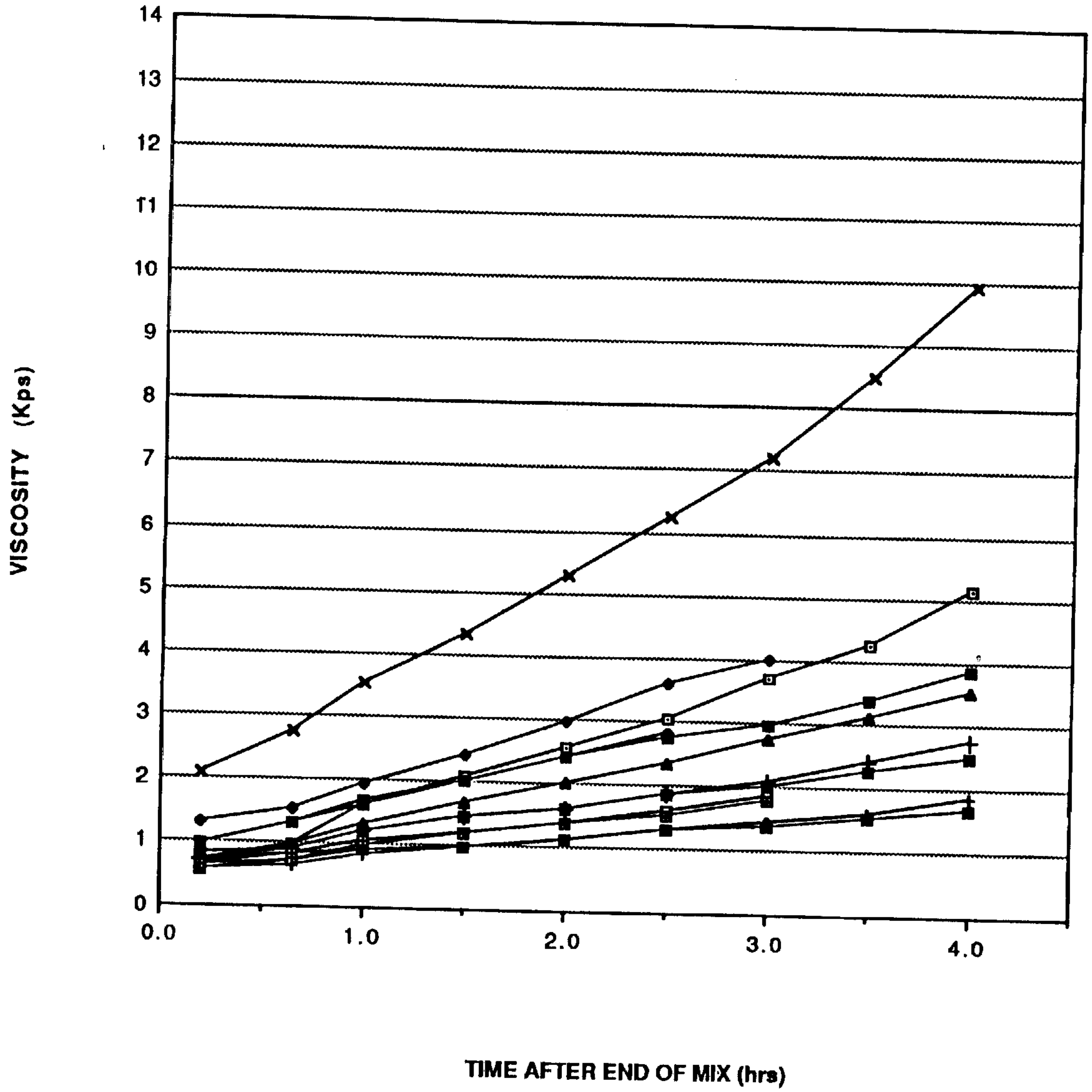
FIGURE 8
JAYGO 40-LB LINER MIX'S

	MIX NO.	EOM VISC (poise)	EOM TEMP (F)
*JAYGO 24			
JAYGO 25	310555	1600	150
JAYGO 26	310554	746	154
JAYGO 27	309958	1204	147
JAYGO 28	309961	1200	152
JAYGO 29	309975	938	149
JAYGO 30	309976	1264	153
JAYGO 31	310021	557	151
JAYGO 32	310231	844	156
FSM AFT	**310313	N/A	147
FSM AFT	310374	691	154
FSM C/F	310279	518	155
FSM C/A	310711	588	154

* NO VISCOSITY CURVE GENERATED

** SCRAPPED - LOW EOM TEMP.

FIGURE 9
JAYGO 50-LB INHIBITOR MIXES



	MIX NO.	EOM VISC (poise)	EOM TEMP (F)
MIX 1	307836	598	174
MIX 2	307835	1226	145
MIX 3	307838	N/A	145
MIX 4	307837	1030	144
MIX 5	310605	812	145
MIX 6	310604	627	152
MIX 7	310681	678	153
MIX 8	309951	685	139
MIX 9	310113	928	151
MIX 10	310232	534	156
I PS-3	310198	570	154
FSM C/F	310393	1264	157
FSM C/A	310391	653	156
FSM C/F	310392	659	157

NOTE: MIX 6 THE VERTICAL TRRANSVERSING BUTTON WAS NOT TURNED ON.

NO CURVE WAS GENERATED FOR FSM C/F MIX NO. 310392