Instrumented Trials on 'Destiny' July 1991

Consultancy Report No. 46

September 1991

Sea Fish Industry Authority
Seafish Technology

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1. Background

A Seafish trials team carried out an instrumented sea trial in December 1989 to investigate the causes of excessive exhaust temperature on the main propulsion engine. A report on these trials was produced as CR 7. It was confirmed that the engine was not subject to overload in any of its fishing or steaming modes. The worst situations involved seining activities in which the engine was required to provide power to the hydraulic seine winch and rope reels while running at low speeds (500 to 700 engine revs/min) in order to limit forward thrust from the propeller.

On investigation of the available data on engine performance characteristics, a discrepancy was noted in that the maximum available power at the lower engine speeds (say below 700 revs/min) could not be delivered without exceeding the declared upper limit on exhaust temperature of 600°C. This was later confirmed by trials of an engine of the same type on the manufacturers test bed.

With no immediate solution being offered by the engine manufacturers, it was decided that the winch drive would be transferred from the main engine to a new auxiliary engine. This would provide some relief from power demands on the engine when working with seine gears and also when hauling (but not towing) trawl gears.

Arrangements were made to convert the vessel to the new layout. A number of tests were also made by the main engine manufacturer to improve the operating circumstances of the engine. The changes involved, inter alia, replacements of fuel pumps and turbo blowers.

The vessel was eventually converted in early 1991 and an improvement in operating parameters was immediately apparent. Seafish staff carried out a further instrumented trials in July 1991 to confirm the extent of the improvement.

The results of both sets of trials have now been collated in a common format for cross reference.

2. Conclusions

(i) In comparable operating conditions the engine exhaust temperatures are now much lower than before. As an example the full speed free steaming power (measured at about 380 hp on both occasions) was achieved at exhaust temperatures of 514°C in the 1991 trials, compared to a value of 579°C in the 1989 trials.

(ii) The exhaust temperatures recorded in July 1991 are in line with manufacturer's predicted values on data sheets provided when the engine was new. This was not the case on previous trials.

(iii) Seining operations can now be carried out without expectation of high exhaust temperatures. However a penalty carried is the need to install a separate engine to carry winch loadings during seining.

(iv) The defied power characteristic of the engine identifies the maximum available horsepower from the engine at speeds in the range 600 to 1200 revs/min. (Kelvin Document File No. TF/6/1-88 Data Sheet 1001/1). Only when a companion document (Data Sheet 1001/2) is studied can it be seen that the manufacturers own stated limits on maximum exhaust temperature will be exceeded if all available power is demanded at engine speeds below about 700 revs/min. This latter information is critical to design of the power train on vessels which operate with the demersal seine net.

(v) Power demands on the engine during seining in the 1989 trials were just within the defined power characteristics of the engine, but without any allowance for derating to meet exhaust temperature limits. It might have been possible to carry out

minor adjustments to the vessel operating pattern to remain with exhaust temperature limits if the engine had not also had a fault which caused higher than expected exhaust temperatures under all operating conditions. In the event the decision to relieve the engine of a major load component (the winch power demands) was inevitable, given the engine manufacturers' failure to devise solutions to the problem within a reasonable time of it being brought to their attention.

3. Conversions To Vessel Following Earlier Trials

The vessel had been converted since the earlier trials to allow of complete separation of propeller and winch drives. The main winch pump and seine net reel/power block pumps are now driven by an auxiliary diesel engine. The auxiliary engine and pumps all run at the same speed which is varied between 1200 and about 1650 runs/min. dependant on whether winch speed requirements are in the slow or fast regimes when hauling the seine rope. The variable delivery pump control mechanism is retained and is used to provide close control of the winch speed.

4. Trials Narrative

The vessel steamed from Whitehills at 09.30 hours on Friday 12th July 1991. The instrumentation package fitted on earlier trials had been refitted to allow replication of all earlier tests. Main features of installation were :

(i) Strain gauging of propeller shaft to allow continuous measurement of shaft torque.

(ii) Fitment of speed counter device to propeller shaft to provide shaft speed and (in conjunction with (i) above) transmitted power.

(iii) Fitment of fuel flow measurement system to measure main engine fuel consumption (the vessel's own equipment was also in use).

(iv) Fitment of pressure transducers on main and auxiliary hydraulic circuits and of speed counters on seine winch and rope reels.

(v) Fitment of towed vessel speed log.

(vi) Fitment of single point towing warp loadmeter (for use with trawl gear).

(vii) Fitment of temperature transducer on the exhaust manifold.

(viii) Fitment of pressure transducer on the turbocharger delivery manifold.

All the parameters noted above could be continuously monitored, and records maintained of average values over defined periods of time and of the time of record.

Visual records were made of a number of other parameters, in some cases to supplement the continuous electronic records. These parameters were :

- Engine speed from ship's instrument
- Electrical demands from the 110v and 24v system
- Exhaust temperatures (using the vessel's own instrument)
- Air temperatures within the engineroom
- Boost air pressure on the main engine

Once at sea the earlier trials sequence was duplicated. The trials thus comprised :

(i) A series of free steaming trials at different engine speeds
(ii) A complete Scottish Seine cycle
(iii) One tow with the vessel's own trawl gear

including periods of towing with a range of engine speeds. On return to port a bollard pull trial was carried out at a range of engine speeds.

5. Discussion of Results

The results from the trial are shown in Table 1A to 3B and are shown graphically in Figures 1 to 5. For convenience of reference, the results from the trials in December 1989 are shown in the same format in Tables 11A to 12B and in Figures 11 to 15. It will be noted that bollard pull trials were not carried out in the earlier trials sequence.

Figures 1 and 11 show the total main engine power demand (i.e. the combination of propulsion, electrical, seawater, pump, shafting losses etc) on the engine in the different modes tested. Figure 11 also shows the combination of the above powers plus that power taken by the winch demand during the Scottish Seine cycle. The figures also show the manufacturer's defined maximum horsepower at different engine speeds. No allowance has been made for reduction in available power to take account of increase in exhaust temperatures at maximum power at reduced engine speeds. Thus the power limits shown are not necessarily valid at engine speeds lower than 700 rev/min.

The values measured are sensibly constant for the two trials with the exception of the Scottish Seine sequence. When the seine winch power is not provided by the main engine the power demands during the Scottish Seine cycle are seen to approximate to a steaming or towing load consistent with the low engine speeds

used during this cycle. Thus Figure 1 (July 91) shows power demands during the seine cycle to be well below the available power line irrespective of whether allowance is made for derating as noted above. This contrasts with Figure 11 (Dec. 89) which showed that power demand from the winch (at as much as 90 hp) dominated the total power demand value and that total demand approached the limits of power available during the Scottish Seine sequence.

Figures 2 and 12 show the propulsion power demands during the different cycles and show agreement between the values recorded on the two tows.

Figures 3 and 13 show the exhaust temperatures recorded during the trials. Also shown is the manufacturers test bed values for exhaust temperatures with the engine running at full power at different speeds. The reduction in recorded temperatures during the July 91 trials (Figure 3) will immediately be noted. In fact the difference is greater than would appear at first sight since the maximum powers recorded in the July 91 trails were higher than had been recorded in December 1989, particularly in the towing mode. In the December 1989 trials maximum power take off had been restricted to 329 hp at 996 revs/min at which point exhaust temperatures had risen to 596°C and further increases would have been unacceptable. In the July 91 trials the power was taken up to 362 hp at 1070 revs/min., exhaust temperatures at this time being no higher than 511°C.

In the July 91 trials it will be seen that exhaust temperatures corresponded well with those which might be expected by reference to the manufacturers declared characteristics for the engine. This contrasts with the December 89 trials when exhaust temperatures were as much as 120°C above those which might have been predicted.

Boost Pressure recorded during the trials are shown on Figures

4 and 14 together with manufacturers characteristics for the engine as originally supplied. It will be noted that boost pressure values are similar to those recorded before (the highest recordings in the July 91 trials were made at powers which were not achieved in the December 89 trials). The use of boost pressure which exceed the original specification is probably of no significance given the changes in specification of the turbocharger and aftercooler now fitted to the engine.

The Specific Fuel Consumption values for the two trials are shown in Figures 5 and 15. A disclaimer must immediately be made against the absolute accuracy of specific fuel consumption values calculated from field trials, given the possible limits of accuracy in measuring the parameters used in the calculations. However, an improvement in consumption is detectable particularly in the towing mode, where specific fuel consumption is now seen to remain sensibly constant over the range of speeds used when towing the gear whereas it formerly increased rapidly at engine speeds above about 910 revs/min. As this range is that used in commercial fishing operations a small but useful saving in fuel costs should accrue during trawling operations.

6. Conclusions From the Series of Trials

6.1 The main conclusion that may be drawn from the series of trials is that the owners comments regarding the inability of the engine as supplied to deliver its quoted performance without also operating at unacceptably high exhaust temperatures were fully justified. The most recent series of modifications to the engine have shown that the engine may now be expected to meet the original specification as far as power/exhaust temperatures are concerned, but this was certainly not the case when the engine was new.

6.2 Had problems identified in 6.1 above not been present it is possible that the original expectation of running the vessel on a single engine at all times might have been met,

either with the installation as fitted and originally used or possibly by some minor conversion such as adjustment of the pump delivery controls to limit the power demand.

6.3 Given that the typical operating cycle when using the Scottish Seine gear makes power demands on the engine which must be met when the engine is running at its slowest speeds it is vital that information be provided as to the possible power availability at these speeds. Some confusion was caused in the case of the engine provided for this vessel in that the published power characteristic made no allowance for the limits set by exhaust temperature considerations at low engine running speeds.

6.4 In comparison with some other engine designs the engine as fitted offered a relatively flat torque characteristic (i.e. engine power nominally proportional to engine speed over the operating speed range). As such the engine appeared to meet the criteria of providing adequate performance against all demands of the Scottish Seine cycle including winch powers demands. Thus the original engine room concept for this vessel was perfectly practicable, in terms of information available to the designer.

TRIAL RECORDS MFV DESTINY Trials Date : 12/7/91

RUN Reference	1041 Steaming	1049 Steaming	1058 Steaming	1105 Steaming	1113 Steaming	1120 Steaming
SHAFT RPM	194	225	251	282	312	352
SHAFT TORQUE - lbs.ft	1190	1673	2207	2909	3741	4952
HYD. PRESS.						
ELEC(110v) - amps	20	20	40	30	43	40
ELEC(24v) - amps	80	83	92	85	85	85
MAIN ENGINE FUEL CONS'N - L/Hr	15.7	23.8	31.3	40.7	55.6	82
VESSEL SPEED - knots	6.53	7.3	7.84	8.36	8.64	9.3
EXHAUST TEMP.(mean)	310	326	326	393	433	514
BOOST PRESS	0	0	2	6	13	25.5
HYD. PRESS. on REELS						
HYD BOOST PRESSURE						
TOWING PULL - Tonnes						
SEINE BARREL SPEED						
TOW WARP DECLINATION						
ENGINE ROOM TEMP. @ FILTER	26	26	26	27	28	29

TABLE 1A

TRIAL RECORDS MFV DESTINY Trials Date 12/7/91

RUN Reference	1041 Steaming	1049 Steaming	1058 Steaming	1105 Steaming	1113 Steaming	1120 Steaming
SHAFT RPM	194	225	251	282	312	352
ENGINE RPM	**665**	**772**	**861**	**967**	**1070**	**1207**
SHAFT HP	**44**	**72**	**105**	**156**	**222**	**332**
Gearbox Losses_ 5%	2	4	5	8	11	17
Hyd Winch Power						
Shafting	3	3	4	4	5	5
SW Pump	9	10	11	13	14	16
Elec. Load	6.8	6.9	10.9	8.8	11.2	10.7
Total Aux. T/O Power	*21*	*24*	*31*	*34*	*41*	*48*
TOTAL ENGINE H.P.	**65**	**96**	**137**	**190**	**263**	**380**
Fuel Cons-Gm/Kw.hr	277	284	261	244	241	246
(lb/Bhp.hr)	0.46	0.47	0.43	0.40	0.40	0.40
HORIZONTAL PULL - Tonnes	0	0	0	0	0	0

TABLE 1B

TRIAL RECORDS MFV DESTINY Trials Date : 12/7/91

RUN Reference	1144 Sh Seine	1157 Sh Seine	1214 Haul Se	1225 Haul Se	1246 Haul Se	1252 Haul Se	1255 Haul Se	1300 Haul Se	1306 Haul Se	1346 Towing	1354 Towing	1401 Towing	1409 Towing	1416 Towing
SHAFT RPM	297	346	221	214	224	236	234	223	163	219	232	264	280	312
SHAFT TORQUE - lbs.ft	3392	3576	2237	2324	2486	2614	1398	1418	1492	2616	2940	3795	4305	5385
HYD. PRESS. (main)	207	212	1060	1542	1697	1690	1636	1265	1560					
(Boost)	82	79	87	88	83	78	92	93	93					
ELEC(110v) - amps	40	45	43	22	22	22	22	22	22	22	56	22	22	22
ELEC(24v) - amps	85	82	83	80	81	81	81	80	82	79	86	82	82	82
MAIN ENGINE FUEL CONS'N - L/Hr	47.5	49.6	25	25	28	29	16	15.7	16	30.4	36	47.8	56.4	77
AUX . ENG. FUEL CONS'N - L/Hr	2.5	2.5	10	10.8	12	13	25	21	22					
VESSEL SPEED - knots	8.3									2.1	2.41	2.95	3.21	3.6
EXHAUST TEMP.(mean)	412	450	388	385	395	410		305		380	395	434	452	511
BOOST PRESS	19	8	0	0	0	0	0	0	0	1	3.5	9	13	24
HYD. PRESS. on REELS	153	157	2340	2305	2257	2203	2214	2279	2318					
HYD BOOST PRESSURE	82	79	87	88	83	78	92	93	93					
TOWING PULL - Tonnes										2.16	2.4	2.95	3.3	4.1
SEINE BARREL SPEED			19	25	37	49	115	106	104					
TOW WARP DECLINATION										26.5	26.5	24.7	23	22
ENGINE ROOM TEMP.	28	28	30	31	31	31	31	31	31	31	32	33	34	34

TABLE 2A

TRIAL RECORDS MFV DESTINY Trials Date : 12/7/91

RUN Reference	1144 Sh Seine	1157 Sh Seine	1214 Haul Se	1225 Haul Se	1246 Haul Se	1252 Haul Se	1255 Haul Se	1300 Haul Se	1306	1346 Towing	1354 Towing	1401 Towing	1409 Towing	1416 Towing
SHAFT RPM	297	346	221	214	224	236	234	223	163	219	232	264	280	312
ENGINE RPM	**1018**	**1186**	**758**	**734**	**768**	**809**	**802**	**765**	**559**	**751**	**796**	**905**	**960**	**1070**
SHAFT HP	**192**	**236**	**94**	**95**	**106**	**117**	**62**	**60**	**46**	**109**	**130**	**191**	**230**	**320**
Gearbox Losses_ 5%	10	12	5	5	5	6	3	3	2	5	6	10	11	16
Hyd Winch Power														
Shafting	5	5	3	3	3	4	4	3	3	3	4	4	4	5
SW Pump	13	15	10	9	10	10	10	10	7	10	10	12	12	14
Elec. Load	10.7	11.4	11.1	7.2	7.2	7.2	7.2	7.2	7.3	7.1	13.6	7.3	7.3	7.3
Total Aux. T/O Power	*38*	*44*	*29*	*25*	*26*	*27*	*24*	*24*	*19*	*26*	*34*	*33*	*35*	*42*
TOTAL ENGINE H.P.	**230**	**279**	**123**	**119**	**132**	**145**	**87**	**84**	**66**	**135**	**164**	**223**	**265**	**362**
Fuel Cons-Gm/Kw.hr	235	202	231	239	242	228	210	214	278	257	250	244	243	242
(lb/Bhp.hr)	0.39	0.33	0.38	0.39	0.40	0.38	0.35	0.35	0.46	0.42	0.41	0.40	0.40	0.40
HORIZONTAL PULL - Tonnes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.93	2.15	2.68	3.04	3.80

TABLE 2B

TRIAL RECORDS MFV DESTINY Trials Date : 12/7/91

RUN Reference	1530 Bollard	1532 Bollard	1535 Bollard	1546 Bollard
SHAFT RPM	261	279	296	219
SHAFT TORQUE - lbs.ft	4181	4870	5606	2812
HYD. PRESS.				
ELEC(110v) - amps	40	40	40	40
ELEC(24v) - amps	75	75	75	75
MAIN ENGINE FUEL CONS'N - L/Hr	51	61.9	74.5	31.2
VESSEL SPEED - knots				
EXHAUST TEMP.(mean)	485	495	511	395
BOOST PRESS	#N/A	15	23	1.5
HYD. PRESS. on REELS				
HYD BOOST PRESSURE				
TOWING PULL - Tonnes	3.39	4.14	4.74	2.41
SEINE BARREL SPEED				
TOW WARP DECLINATION				
ENGINE ROOM TEMP. @ FILTER				

TABLE 3A

TRIAL RECORDS MFV DESTINY			Trials Date :	12/7/91
RUN Reference	1530 Bollard	1532 Bollard	1535 Bollard	1546 Bollard
SHAFT RPM	261	279	296	219
ENGINE RPM	**895**	**957**	**1015**	**751**
SHAFT HP	**208**	**259**	**316**	**117**
Gearbox Losses_ 5%	10	13	16	6
Hyd Winch Power				
Shafting	4	4	5	3
SW Pump	12	12	13	10
Elec. Load	10.3	10.3	10.3	10.3
Total Aux. T/O Power	*36*	*40*	*44*	*29*
TOTAL ENGINE H.P.	**244**	**299**	**360**	**146**
Fuel Cons-Gm/Kw.hr	238	236	236	243
(lb/Bhp.hr)	0.39	0.39	0.39	0.40
HORIZONTAL PULL - Tonnes	3.39	4.14	4.74	2.41

TABLE 3B

TRIAL RECORDS MFV DESTINY **Trials Date : 21/12/89**

RUN Reference	1315 Steaming	1320 Steaming	1326 Steaming	1335 Steaming	1344 Steaming	1353 Steaming
SHAFT RPM	200.2	226	257	288.5	317	344.5
SHAFT TORQUE - lbs.ft	1459	1897	2453	3219	4032	4897
HYD. PRESS.						
ELEC(110v) - amps	81	60	81	102	90	80
ELEC(24v) - amps	102	102	102	102	102	102
FUEL CONS'N - L/Hr	21.2	27	36	48.9	64	83.9
VESSEL SPEED - knots	6.4	7.1	8.3	8.7	8.8	8.9
EXHAUST TEMP.(mean)	359	380	424	467	519	579
BOOST PRESS	0	2	5	10	15	21
HYD. PRESS. on REELS						
HYD CLUTCH(Fwd. PTO)	120	120	150	160	180	190
TOWING PULL - Tonnes						
SEINE BARREL SPEED						
TOW WARP DECLINATION						
ENGINE ROOM TEMP.						

TABLE 11A

TRIAL RECORDS MFV DESTINY **Trials Date : 21/12/89**

RUN Reference	1315 Steaming	1320 Steaming	1326 Steaming	1335 Steaming	1344 Steaming	1353 Steaming
SHAFT RPM	200.2	226	257	288.5	317	344.5
ENGINE RPM	**686**	**775**	**881**	**989**	**1087**	**1181**
SHAFT HP	**56**	**82**	**120**	**177**	**243**	**321**
Gearbox Losses_ 5%	3	4	6	9	12	16
Hyd Winch Power						
Shafting	3	3	4	4	5	5
SW Pump	9	10	11	13	14	15
Elec. Load	19	15	19	23	20	19
Total Aux. T/O Power	*34*	*33*	*40*	*49*	*52*	*55*
TOTAL ENGINE H.P.	**89**	**114**	**160**	**226**	**295**	**376**
Fuel Cons-Gm/Kw.hr	271	269	256	247	247	254
(lb/Bhp.hr)	0.45	0.44	0.42	0.41	0.41	0.42

TABLE 11B

TRIAL RECORDS MFV DESTINY **Trials Date : 21/12/89**

RUN Reference	1435 Sh Seine	1455 Sh Seine	1510 Haul Se	1526 Haul Se	1538 Haul Se	1550 Haul Se	1554 Haul Se	1604 Haul Se	1645 Towing	1655 Towing	1702 Towing	1715 Towing	1730 Towing
SHAFT RPM	327	332	198	201	198	158	161	157	283	278	256	240	290
SHAFT TORQUE - lbs.ft	4257	4511	2375	2417	2316	1711	1686	1479	4742	4581	3878	3386	4956
HYD. PRESS. (main)			1495	1547	1484	1513	1405	1757					
(Boost)			120	120	120	100	100	100					
ELEC(110v) - amps	159	120	132	110	130	101	100	100	115	103	173	100	100
ELEC(24v) - amps	162	162	162	165	165	165	165	165	117	157	157	157	157
FUEL CONS'N - L/Hr	73	76.9	44	45.6	43.8	42	41	41.8	68.4	66	53	44	74.5
VESSEL SPEED - knots	9.09	9	1.16	1.11	1.27	1.17	1.18	0.7	2.9	2.89	2.51	2.28	3.14
EXHAUST TEMP.(mean)	552	565	575	557	559	650	650	655	558	566	534	510	596
BOOST PRESS	19	19	7	7	7	5	5	5	17	16	10	7	18
HYD. PRESS. on REELS			2620	2556	2563	2306	2337	2397					
HYD CLUTCH(Fwd. PTO)	159	120	200	200	200	200	200	200	150	150	130	130	150
TOWING PULL - Tonnes			1.45	1.5	1.44	1.49	1.37	1.74	3.6	3.47	3	2.72	3.8
SEINE BARREL SPEED			21	22.4	25	97	98	95					
TOW WARP DECLINATION									18	18	18	18	18
ENGINE ROOM TEMP.			27	27	26	27	27	28	29	29	29	29	29

TABLE 12A

TRIAL RECORDS MFV DESTINY **Trials Date : 21/12/89**

RUN Reference	1435 Sh Seine	1455 Sh Seine	1510 Haul Se	1526 Haul Se	1538 Haul Se	1550 Haul Se	1554 Haul Se	1604 Haul Se	1645 Towing	1655 Towing	1702 Towing	1715 Towing	1730 Towing
SHAFT RPM	327	332	198	201	198	158	161	157	283	278	256	240	290
ENGINE RPM	**1121**	**1138**	**679**	**689**	**679**	**542**	**552**	**538**	**970**	**953**	**878**	**823**	**994**
SHAFT HP	**265**	**285**	**90**	**92**	**87**	**51**	**52**	**44**	**256**	**242**	**189**	**155**	**274**
Gearbox Losses_ 5%	13	14	4	5	4	3	3	2	13	12	9	8	14
Hyd Winch Power	0	0	49	50	50	81	79	90	0	0	0	0	0
Shafting	5	5	3	3	3	2	2	2	4	4	4	4	4
SW Pump	15	15	9	9	9	7	7	7	13	12	11	11	13
Elec. Load	35	28	30	27	30	25	25	25	26	25	38	24	24
Total Aux. T/O Power	*68*	*62*	*96*	*93*	*96*	*118*	*116*	*126*	*55*	*54*	*62*	*47*	*55*
TOTAL ENGINE H.P.	**333**	**348**	**185**	**186**	**184**	**169**	**168**	**171**	**311**	**296**	**252**	**201**	**329**
Fuel Cons-Gm/Kw.hr	250	252	271	280	272	282	279	279	251	254	240	249	258
(lb/Bhp.hr)	0.41	0.41	0.44	0.46	0.45	0.46	0.46	0.46	0.41	0.42	0.39	0.41	0.42

TABLE 12B

MFV DESTINY BF 102 PERFORMANCE TRIALS 12 / 7 / 91

BRAKE HORSE POWER

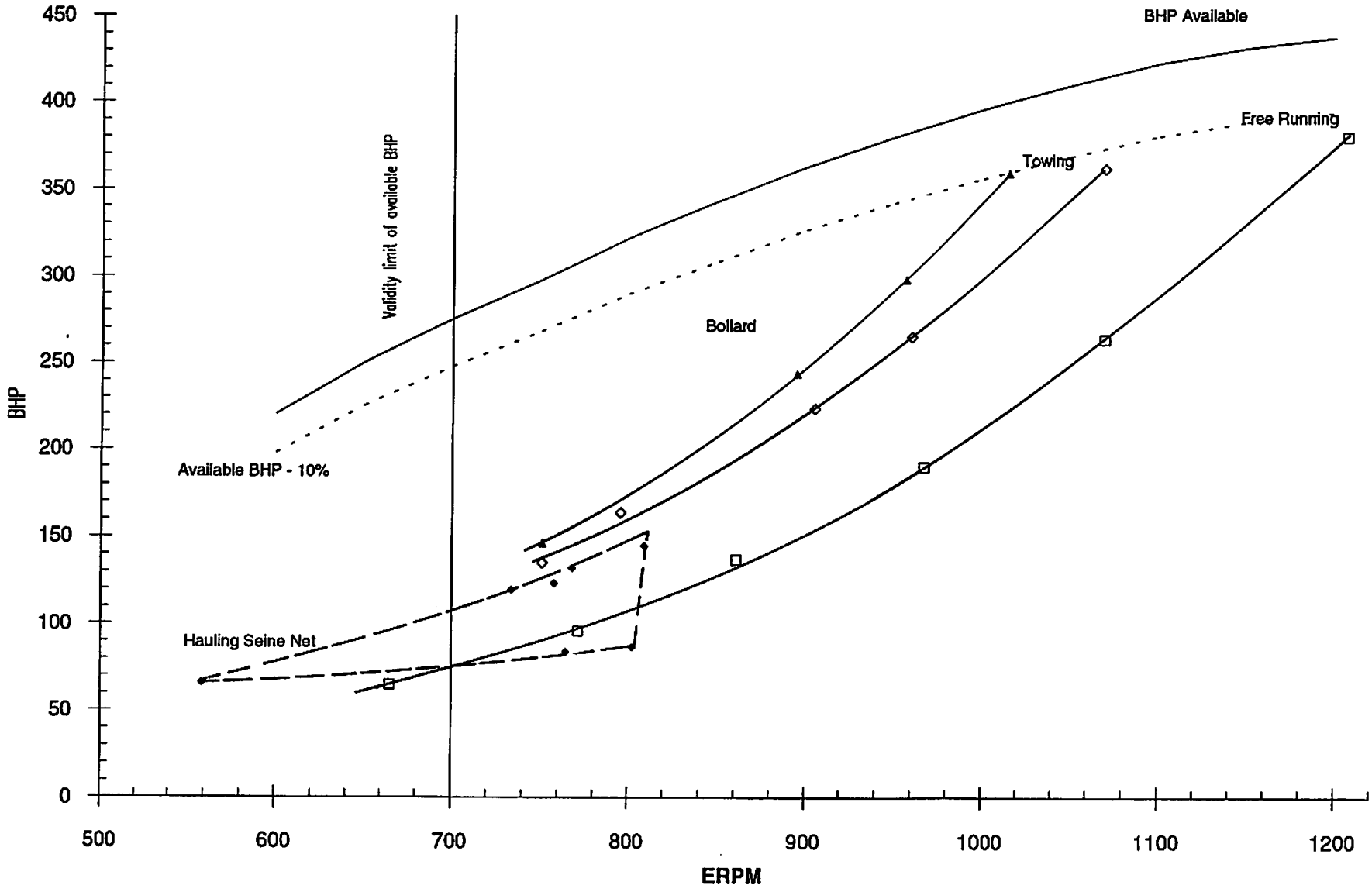

FIGURE 1

MFV DESTINY BF 102 PERFORMANCE TRIALS 12 / 7 / 91

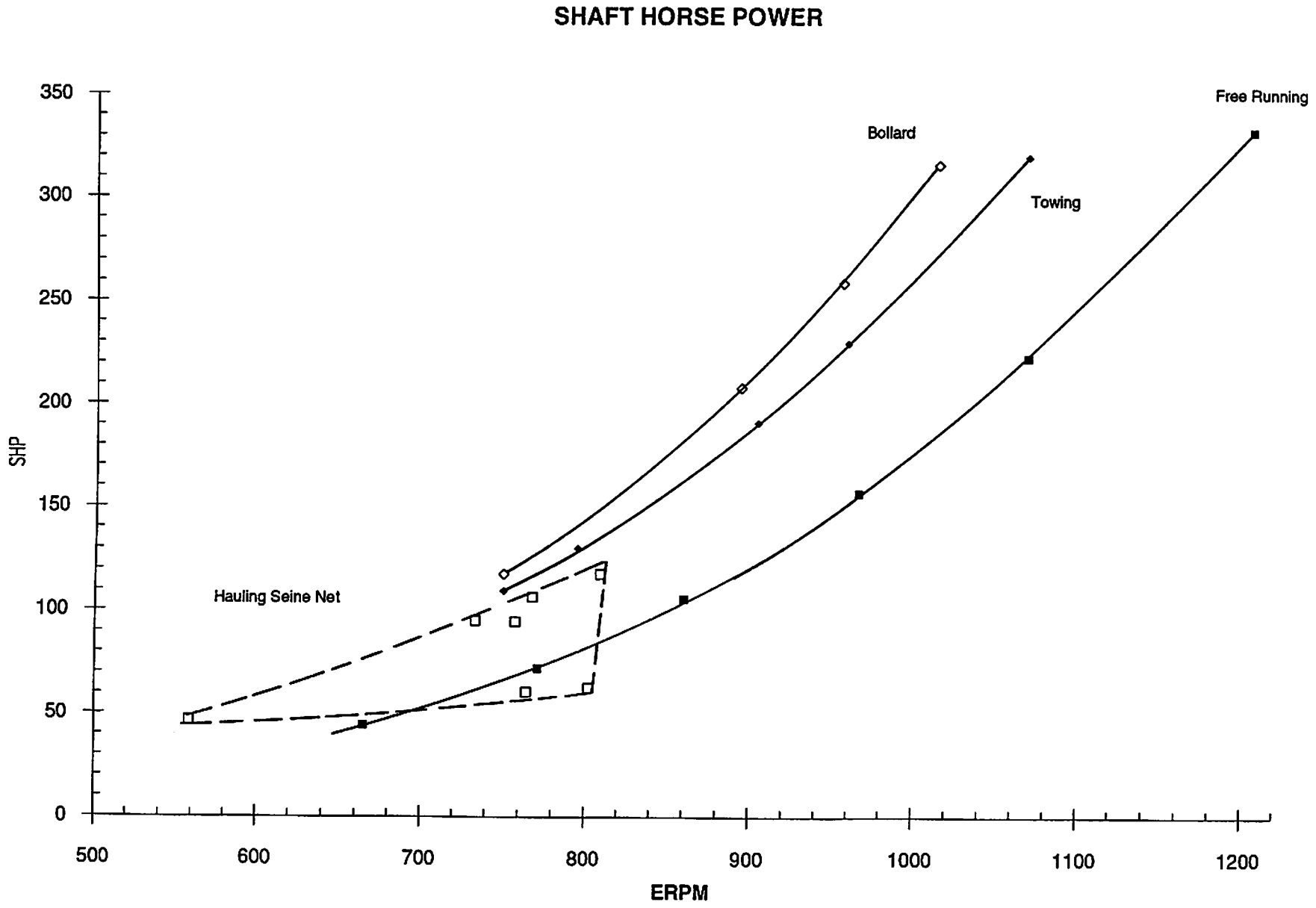

FIGURE 2

MFV DESTINY BF 102 PERFORMANCE TRIALS 12 / 7 / 91

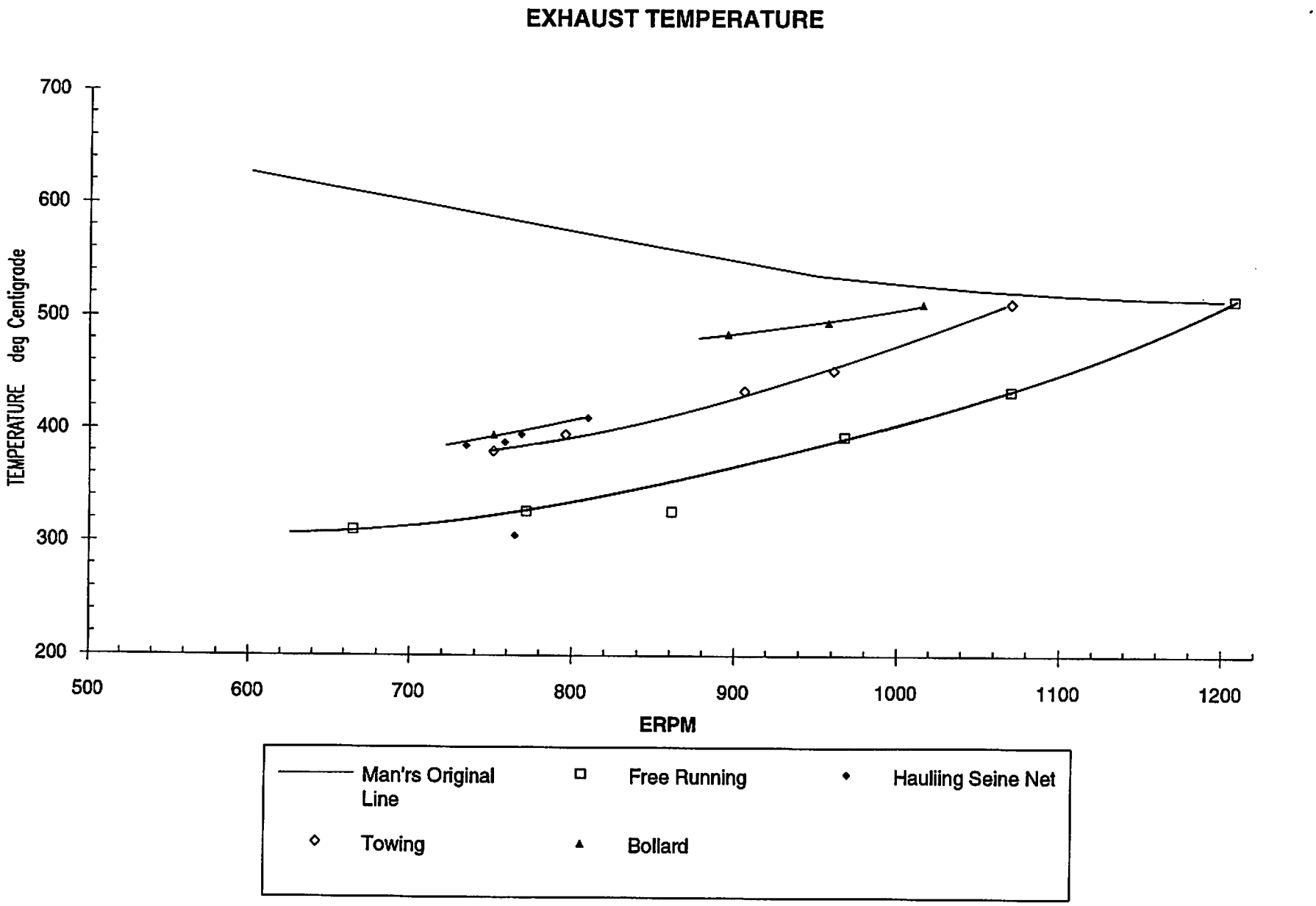

FIGURE 3

MFV DESTINY BF102 PERFORMANCE TRIALS 12 / 7 / 91

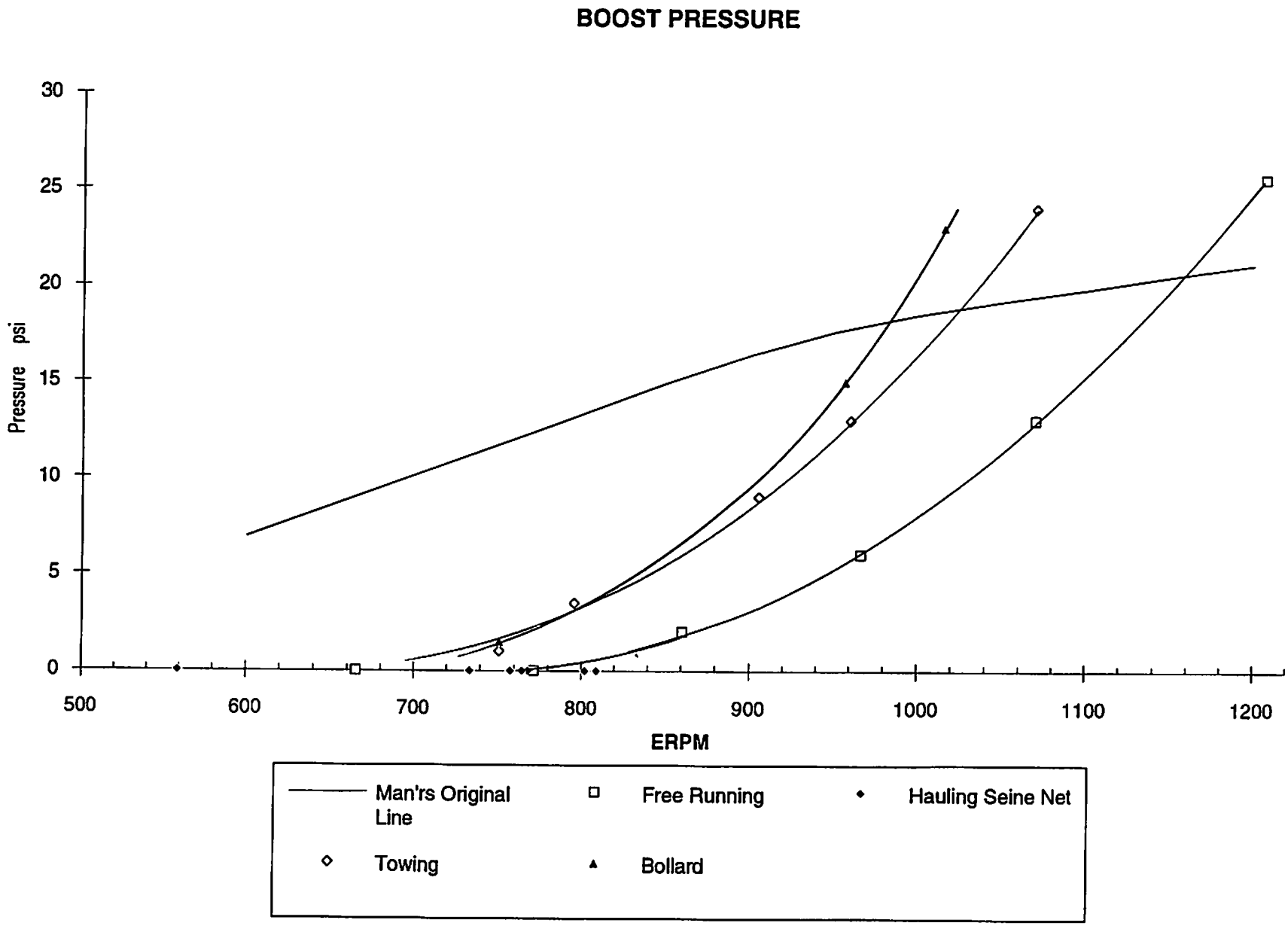

FIGURE 4

MFV DESTINY BF 102 PERFORMANCE TRIALS 12 / 7 / 91

SPECIFIC FUEL CONSUMPTION

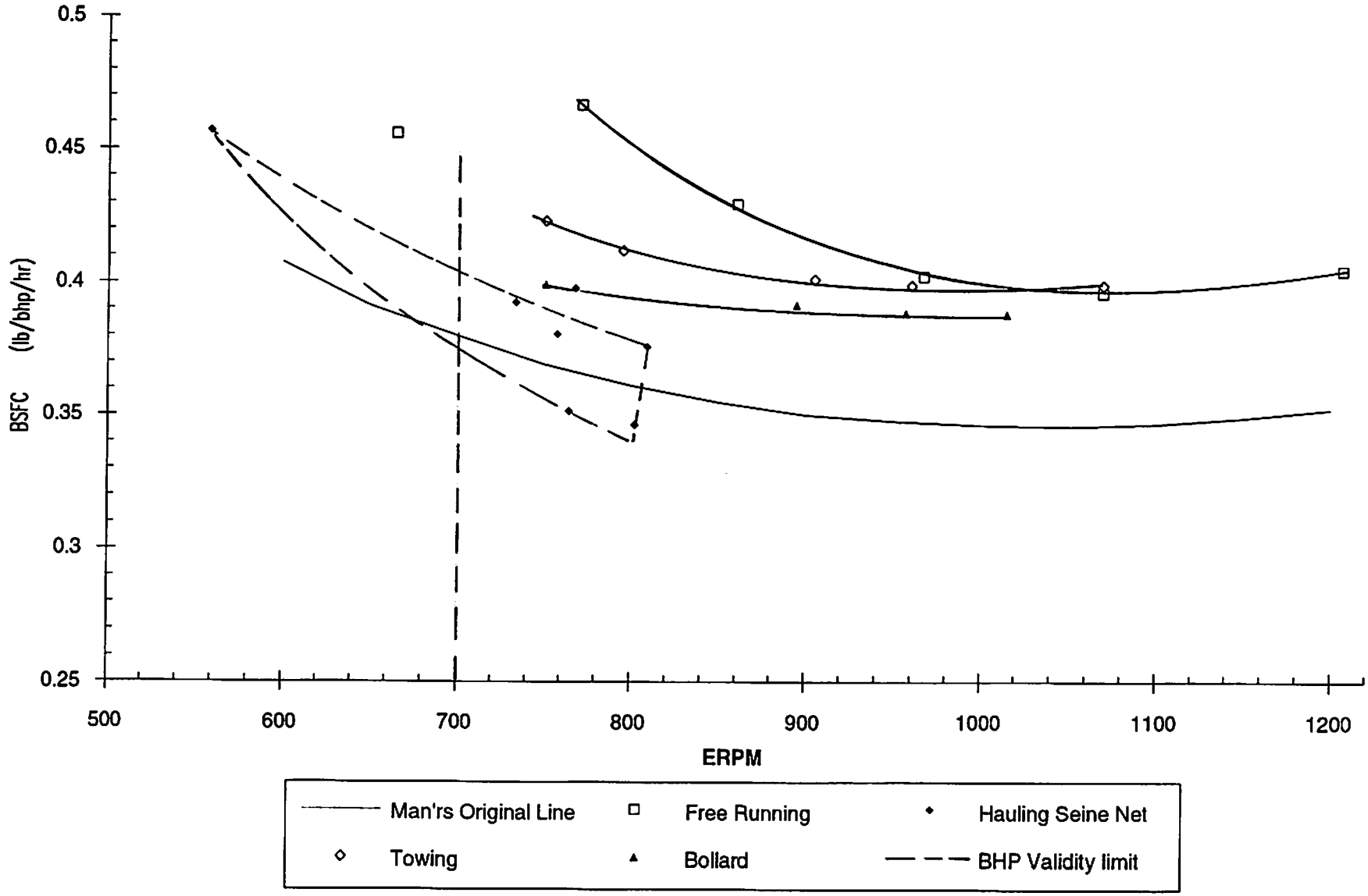

FIGURE 5

MFV DESTINY BF 102 PERFORMANCE TRIALS 21 / 12 / 89

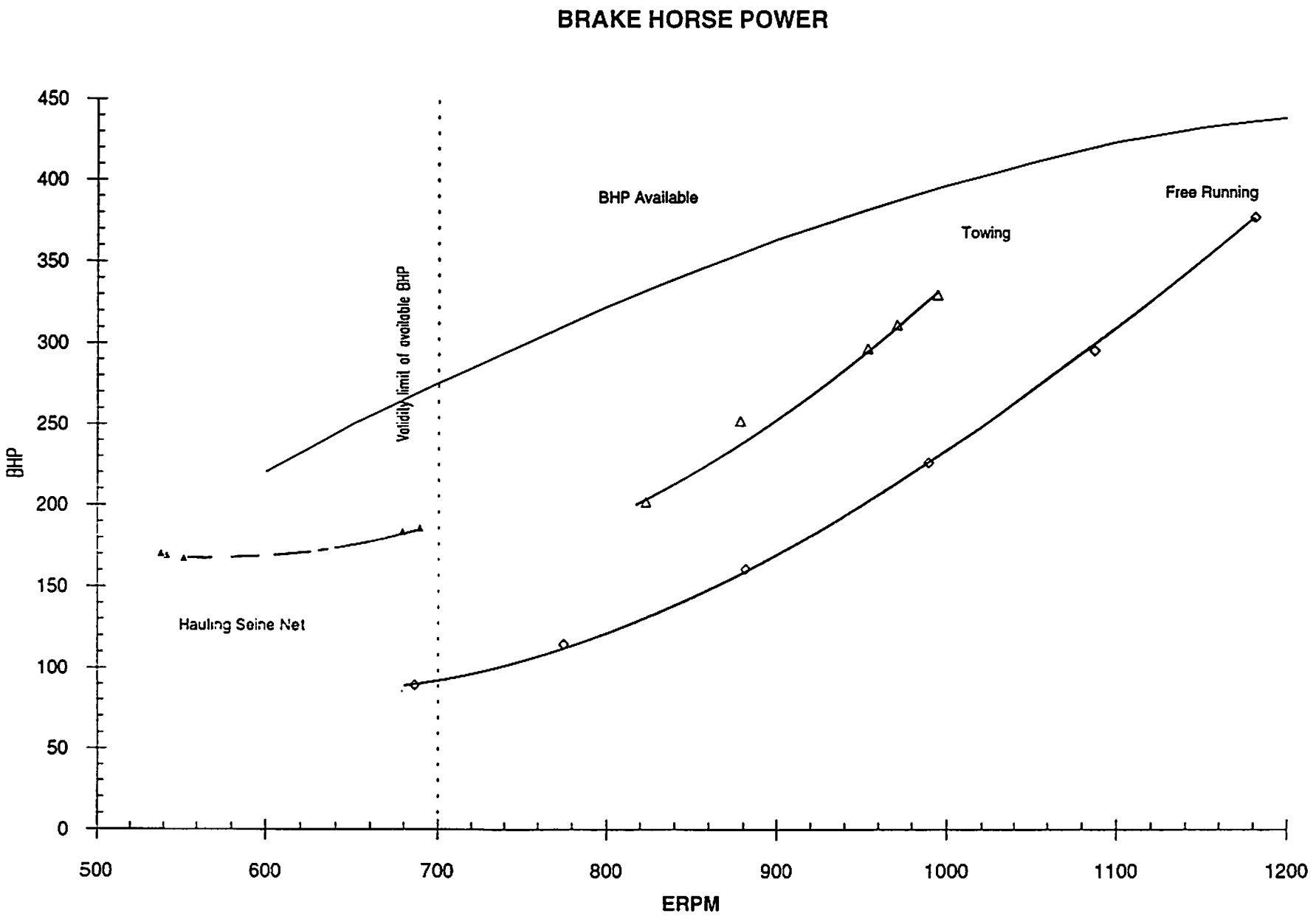

FIGURE 11

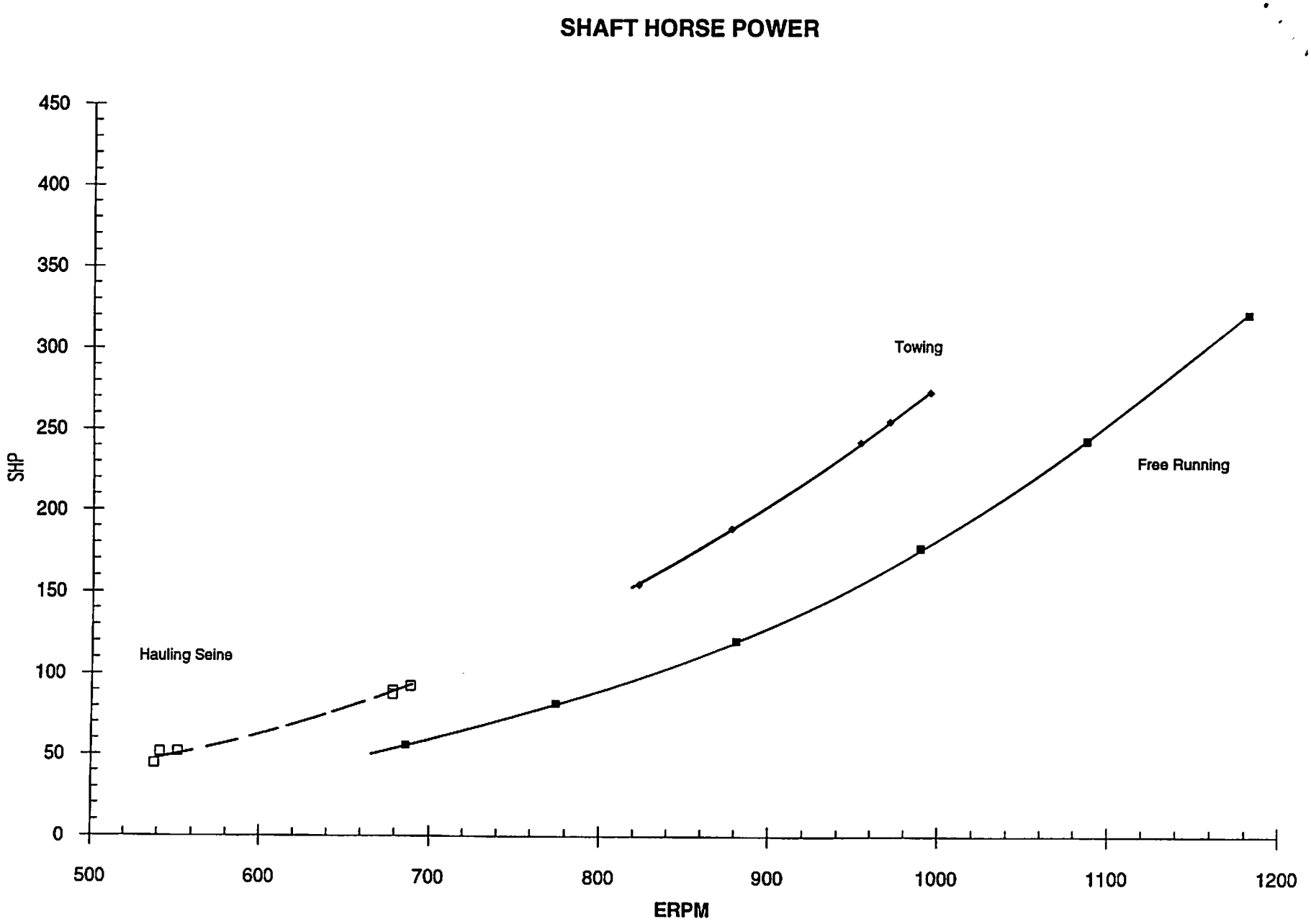
SHAFT HORSE POWER
SHP
450
400
350
300
250
200
150
100
50
0
500
600
700
800
900
1000
1100
1200
ERPM
Towing
Free Running
Hauling Seine

FIGURE 12

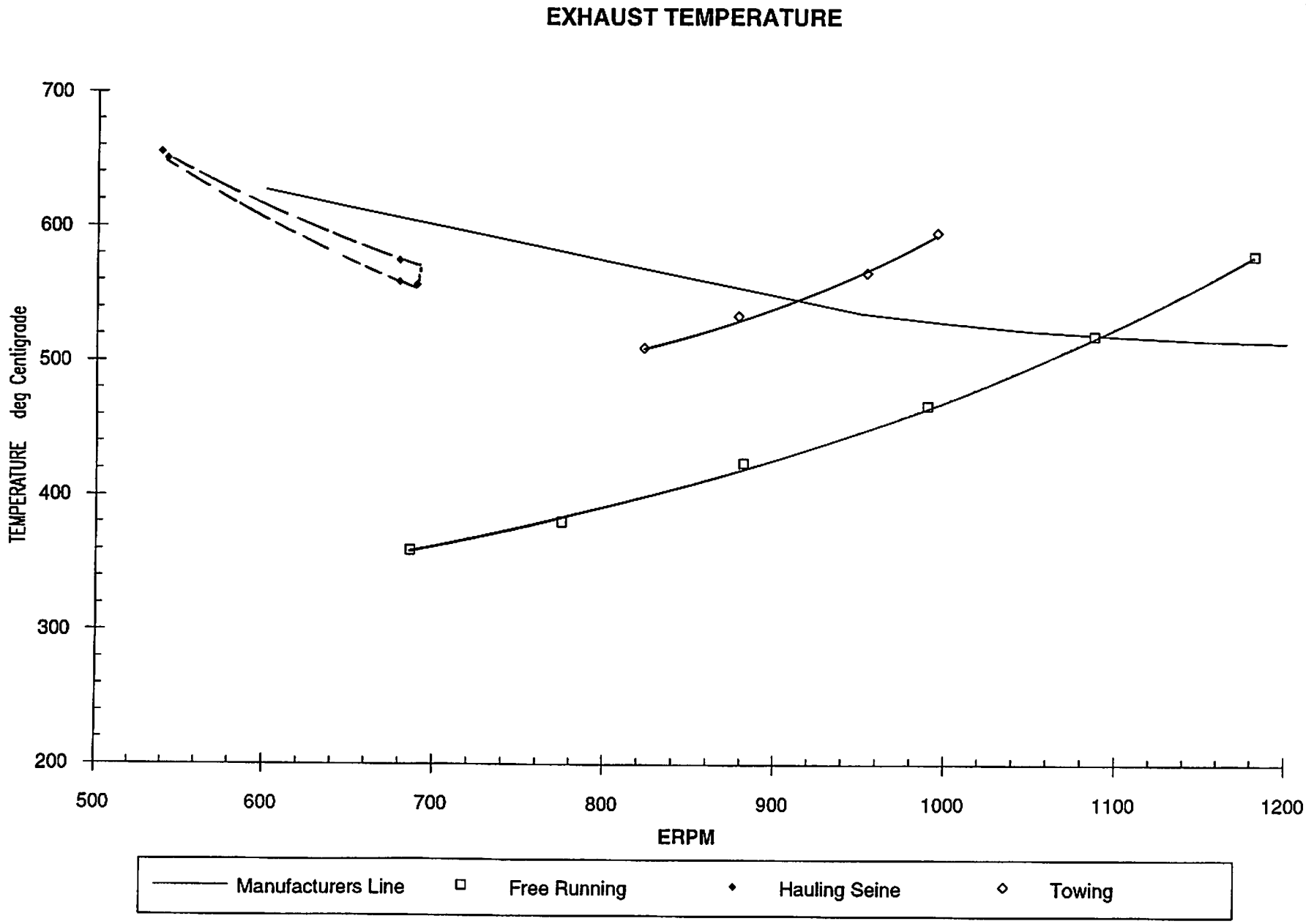
EXHAUST TEMPERATURE
TEMPERATURE deg Centigrade
700
600
500
400
300
200
500
600
700
800
900
1000
1100
1200
ERPM
Manufacturers Line
Free Running
Hauling Seine
Towing

Figure 13

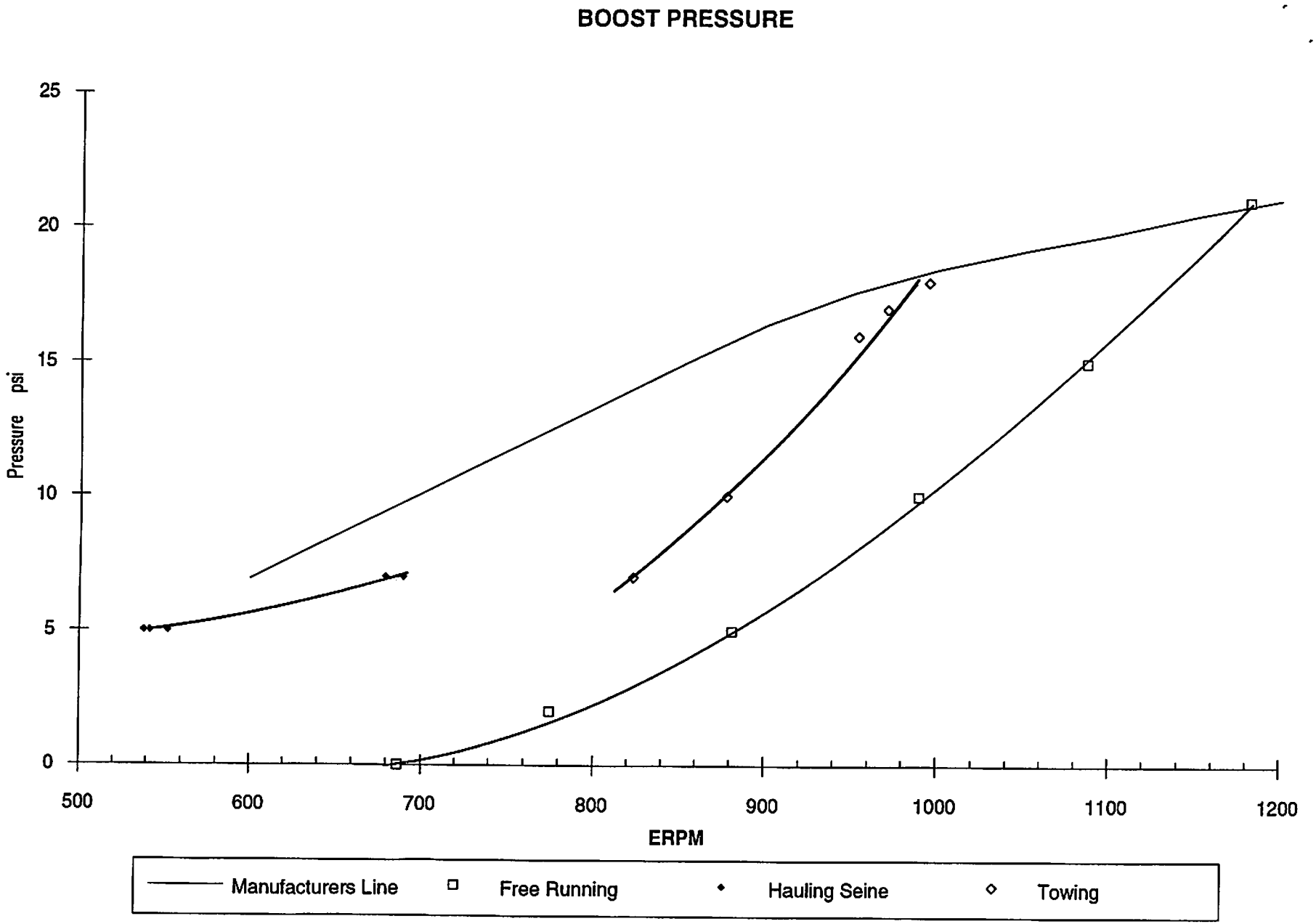
BOOST PRESSURE
Pressure psi
25
20
15
10
5
0
500
600
700
800
900
1000
1100
1200
ERPM
Manufacturers Line
Free Running
Hauling Seine
Towing

FIGURE 14

MFV DESTINY BF 102 PERFORMANCE TRIALS 21 / 12 / 89

SPECIFIC FUEL CONSUMPTION

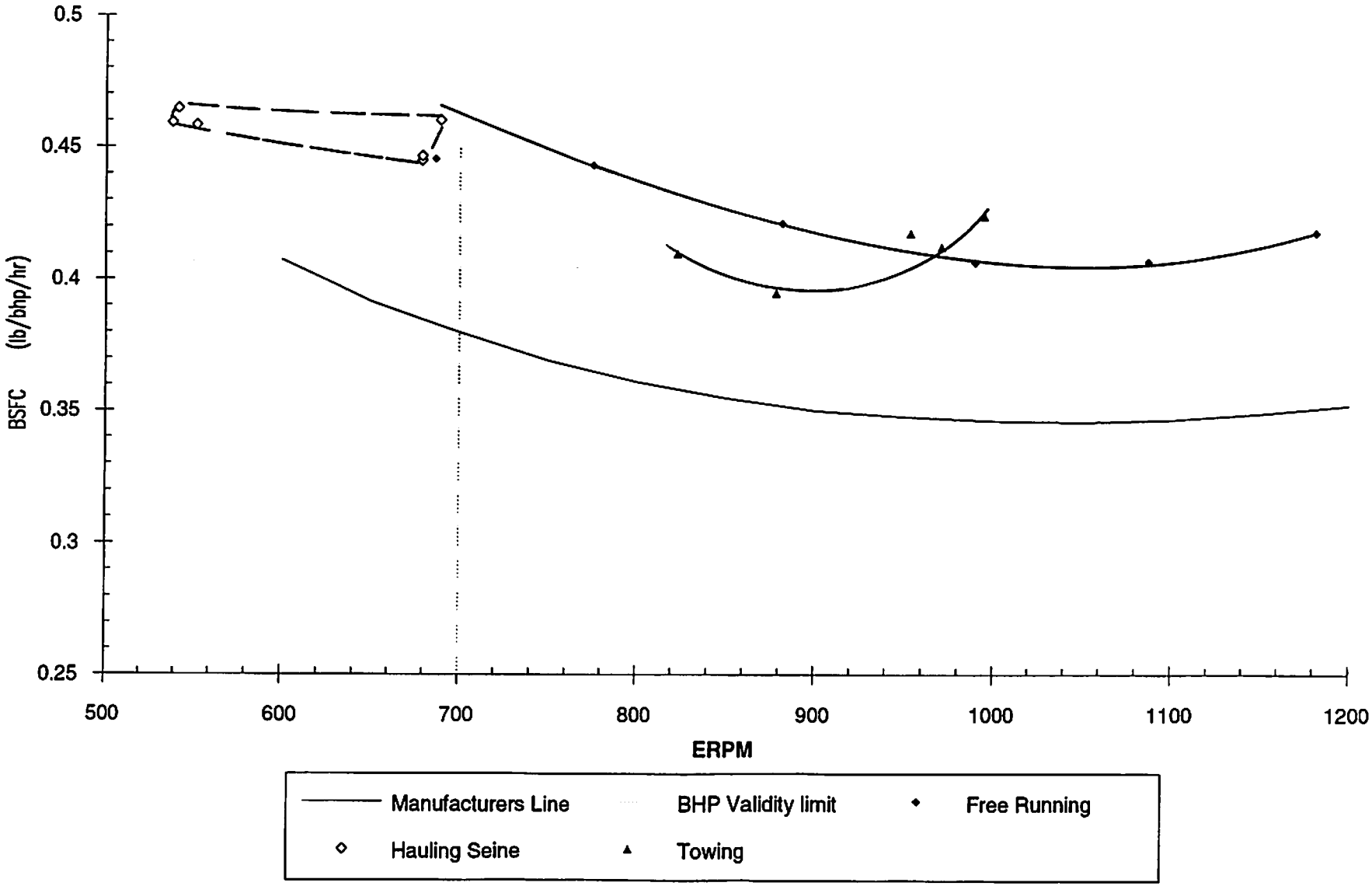

FIGURE 15