

MAN B&W Diesel A/S



Service Letter

No: SL 87-223/UM
September 1987

L50/60/70/80/90MC
K80/90MC/90MC-2
S50/60/70/80MC
Super-VIT Fuel Pumps: Adjustment & Maintenance

Dear Sirs,

Since experience shows that the super-VIT system is often misunderstood or neglected, we have prepared the enclosed instruction, which we hope will contribute to a better understanding of the principles and practical adjustment.

Yours faithfully,

MAN B&W Diesel A/S

A large, stylized handwritten signature in black ink, appearing to read 'J. Schmidt' followed by a long, flowing flourish.

Encl.

HEAD OFFICE (& postal address)
Stamholmen 161
DK-2650 Hvidovre (Copenhagen)
Telephone: + 45 31 49 25 01
Telex: 16573, 16592 manbw dk
Telecopy: + 45 31 49 20 66
Telecopy: + 45 31 49 41 72

DIESEL SERVICE
Stamholmen 161
DK-2650 Hvidovre (Copenhagen)
Telephone: + 45 31 49 25 01
Cables: manbandw
Telex: 31197 manbw dk
Telecopy: + 45 31 49 43 97

PRODUCTION
Tegholmegade 35
DK-2450 Copenhagen SV
Telephone: + 45 31 31 44 33
Telex: 19023 bwforw dk
Telex: 19042 bwforw dk
Telecopy: + 45 31 31 79 20

FORWARDING & RECEIVING
Tegholmegade 35
DK-2450 Copenhagen SV
Telephone: + 45 31 31 44 33
Telex: 19023 bwforw dk
Telex: 19042 bwforw dk
Telecopy: + 45 31 31 55 22

MAN B&W Diesel A/S
Denmark
Reg. No.: 24 231

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K80/90MC/90MC-2
S50/60/70/80MC

1987.09.01
2300/AWW/COS

ADJUSTMENT OF SUPER-VIT FUEL PUMPS

In the interests of rational operation, the optimum functioning of VIT fuel pump systems is of great importance. In realization of this, we have drawn-up the following guidelines, in the hope that they will contribute to a better understanding of the practical adjustment of the pumps.

The instruction is divided into four main sections:

1. BASIC DESIGN DETAILS
2. GENERAL DESCRIPTION OF SYSTEM AND CONTROL MECHANISM
3. ADJUSTMENT OF p_{max} AND BREAK-POINT
4. MAINTENANCE

1. BASIC DESIGN DETAILS

The "super-VIT" (Variable Injection Timing) system, is developed to fulfil the requirement of maintaining the MCR p_{max} under part load conditions, in order to save fuel.

This is achieved by a mechanism which automatically adjusts the commencement of fuel injection, such that the MCR p_{max} is kept constant as the engine load is reduced from 100%, down to a certain pre-specified part-load, known as the **break-point**.

In the super-VIT configuration*, employed on the larger L/K/S-MC engines, and which is the subject of this instruction, the fuel pump plunger is not profiled (i.e. has no extra oblique-cut) but instead, the start of fuel injection (timing) is freely determined by altering the vertical position of the pump barrel, whereby in this system the break-point is fully adjustable.

The pump barrel is moved up and down (relative to the plunger) by means of a rack and pinion, in combination with a double-thread (Fig. 1).

The VIT-rack setting itself is controlled via the regulating shaft position - i.e. according to the engine load.

When running at the break-point, the pump cylinder will be at a low position, i.e. giving early injection and the specified design p_{max} (MCR p_{max}) for the engine in question.

* In the case of the "conventional-VIT" system (i.e. the profile-plunger principle, as used on GB and L35MC + L42MC engines) the break-point is fixed in relation to the pump index - that is to say, the "break" always automatically occurs at the predetermined pump index. Regarding details of this system, we refer to other instructions.

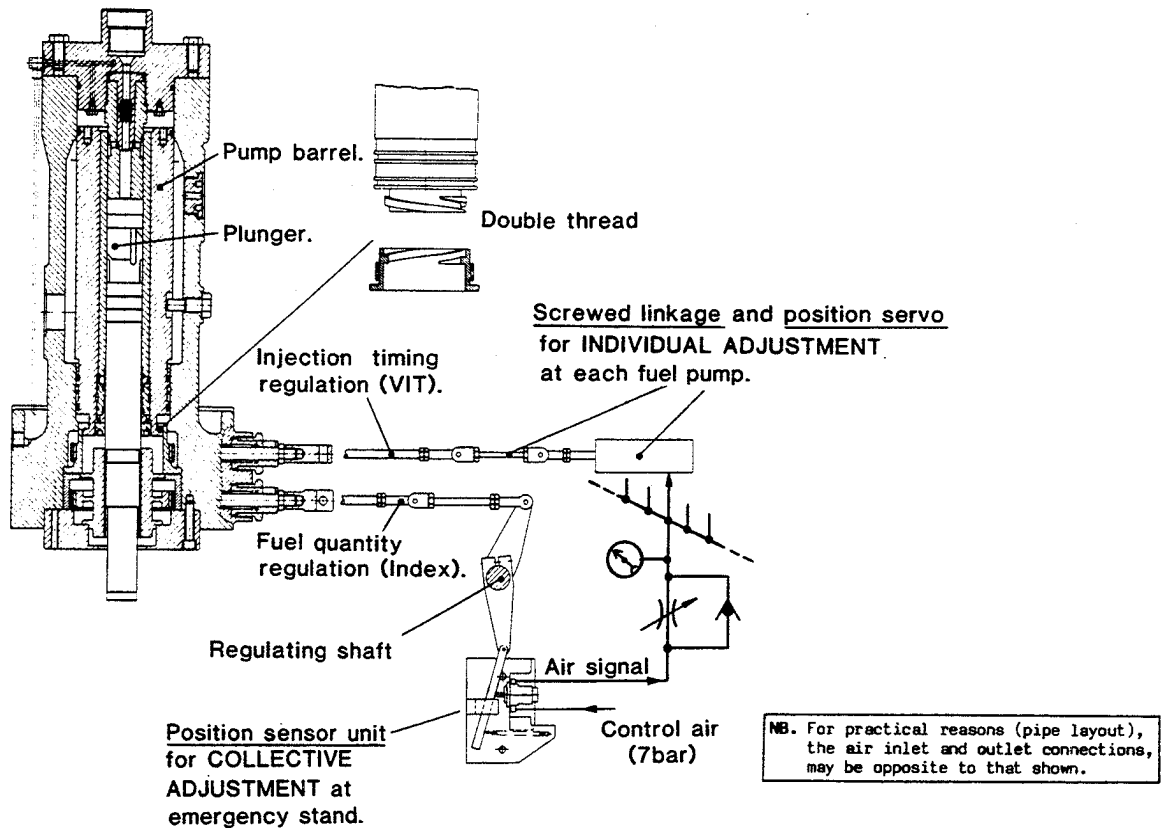


Fig. 1. - SUPER-VIT SYSTEM (Schematic)

2. GENERAL DESCRIPTION OF SYSTEM & CONTROL MECHANISM

As illustrated in Fig. 1, all the VIT-rack position servos are controlled by means of an air signal from a common position sensor valve, which is placed on the emergency stand. The position sensor valve itself is mechanically actuated by linkages from the governor and regulating shaft.

Referring to the position sensor unit on the emergency stand, figs. 2 and 3.

The beam (A) is connected to the regulating shaft (fuel pump index control shaft) via the regulating arm (B) jointed at (C).

The VIT-system is "out-of operation" at low loads. This is in order to avoid frequent changes of pump lead (VIT-index) during manoeuvres.

At zero load, the beam (A) is fully lifted, and the position sensor (D) gives zero control pressure to the position servos at each fuel pump, such that a delayed injection timing is achieved (compared with an engine without super-VIT).

As the engine load is increased, this late injection mode continues until the beam (A) has made contact with the sensor pick-up (E), and the resulting control pressure reaches 0.5 bar. These points are illustrated in figs. 3a and 4.

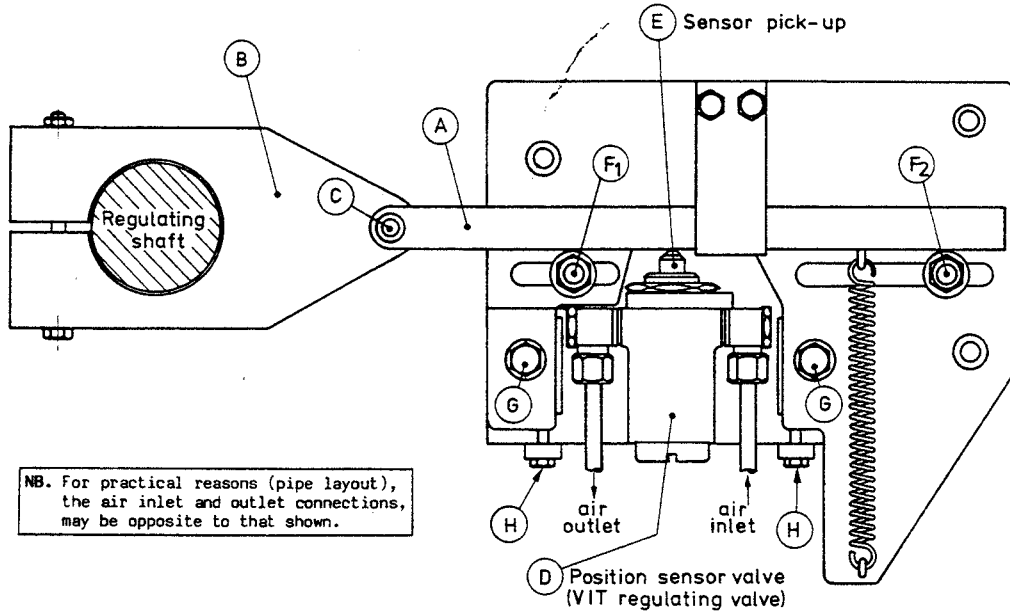


Fig. 2 - COLLECTIVE ADJUSTMENT AT POSITION SENSOR UNIT ON THE EMERGENCY STAND

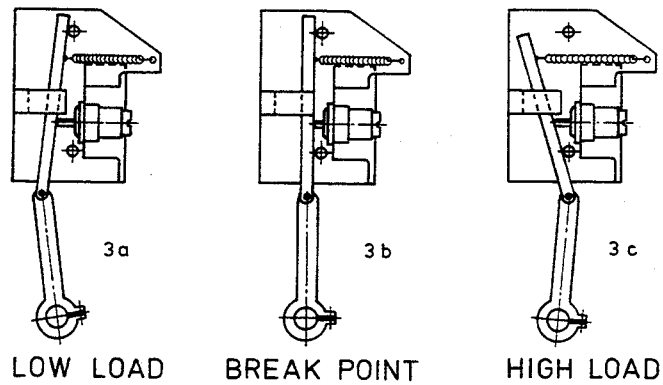


Fig. 3 - OPERATING MODES OF THE POSITION SENSOR VALVE (VIT regulating valve)

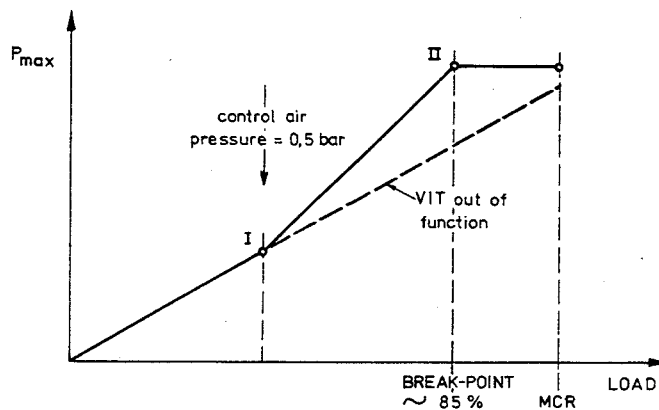


Fig. 4 - P_{max} VARIATION (schematic)



When the engine is then run-up towards approx. 85% MCR, the sensor pick-up (E) is further activated, thus gradually increasing the control pressure. This causes the position servos to alter the VIT-index and thereby advance the injection timing as the load increases, thus tracing line I-II in Fig. 4.

At approx. 85% MCR, the maximum combustion pressure reaches the specified design P_{max} for the engine. At this load, the beam (A) touches both supports (F₁ and F₂), and the sensor pick-up (E) is fully depressed, as shown in Fig. 3b.

If the engine load is then increased above 85% MCR, the beam (A) will rotate around support (F₁), thereby reducing the depression of the sensor pick-up (E), see also Fig. 3c. Correspondingly, the control pressure from the sensor causes the VIT-rack position servos to retard the injection timing at a suitable rate, thereby keeping a constant maximum combustion pressure between approx. 85% MCR and 100% MCR.

Fig. 5 further illustrates how the various parameters vary, as the load is increased from zero to MCR.

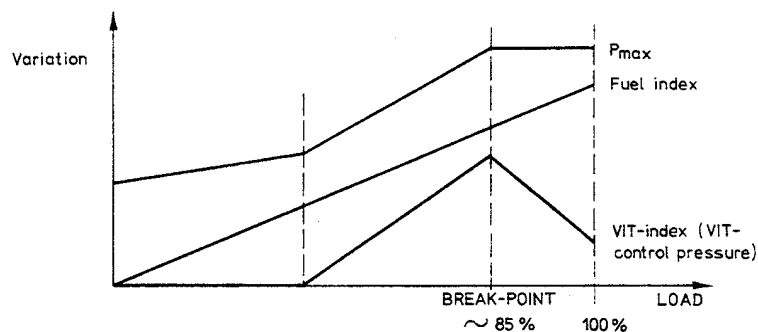


Fig. 5 - PARAMETER VARIATIONS

2.1 VIT starting point

As mentioned, the super-VIT mechanism only operates at control air pressures greater than 0.5 bar. The actual starting-point is pre-adjusted by the engine builder, and no further adjustment should be necessary.

2.2 Timing adjustments

Although it is the regulating shaft which determines the VIT-rack positions, two forms of intermediate adjustment are available (Fig. 6):

- A) Individual P_{max} adjustments (at each fuel pump).
- B) Collective P_{max} adjustment (simultaneously for all pumps).

Both of these adjustment modes can be utilized while the engine is running.

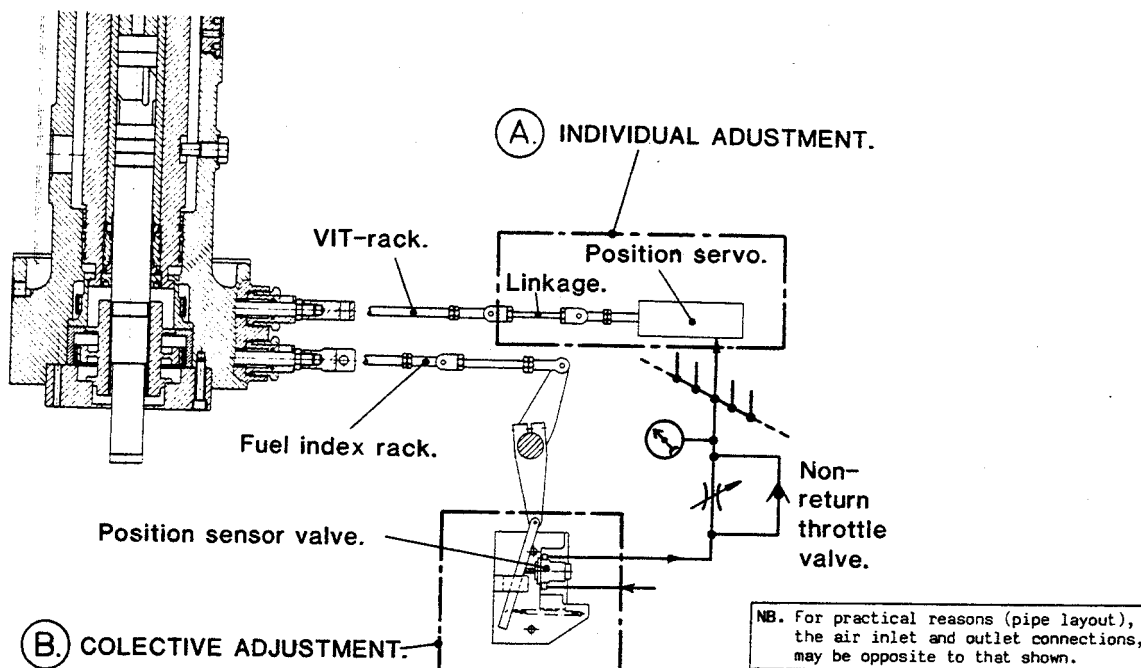


Fig. 6 - ADJUSTMENT MODES (Schematic)

Re A) Individual adjustments at each separate fuel pump are made in order to balance the p_{max} values (i.e. the same maximum pressure in all cylinders, +/- 3 bar). This can be done by two methods:

1. either by physically moving the position servo at each VIT-rack, (only possible on engines where the position servo is mounted in slotted holes).
2. or by adjusting at the threaded connection (linkage-nuts) between the position servo and the VIT control shaft, (i.e. similar to balancing p_i by adjusting the individual pump-indexes).

Re B) Collective adjustment: for the engine as a whole is made at the position sensor unit on the emergency stand. The actual adjustment procedure will depend upon the condition to be corrected.

There are two main conditions that can require re-adjustment:

- varying fuel qualities,
- pump wear and/or significant changes in LCV.

Changed fuel quality: if a fuel is bunkered, having essentially different combustion characteristics, p_{max} might change. In such a case, in order to maintain low SFOC, or to avoid running the engine with too high combustion pressure, the injection timing should be changed. This is done by loosening the bolts (G) (Fig. 2) and turning the adjustment-screws (H), such that the location of the sensor (D), relative to the beam (A), changes in the desired direction. This operation, which can be done while the engine is running, changes the control pressure level, thereby causing all fuel pumps to be advanced (= higher p_{max}) or retarded. See also Fig. 7.



Worn fuel pumps, or significant changes in fuel LCV on volume basis: both of these will change the relationship between the fuel pump index and the necessary injection timing. In order to compensate for this, the following adjustment is carried out.

Stabilize the engine at 85% load. The arm (B) is then loosened, and retightened in such a position that the beam (A) touches both supports (F_1 and F_2). This brings the p_{max} break-point back to 85% MCR.

After this the engine is stabilized at MCR, and the position of the support (F_1) is adjusted, so the p_{max} is equal to the value at 85% MCR (see also Fig. 7).

3. ADJUSTMENT OF p_{max} AND BREAK-POINT

The following describes the adjustment procedure necessary if the fuel cams have been moved.

- 1) With the VIT-rack arms disconnected, run the engine up to 100%. Move the VIT-racks manually, until p_{max} values are equal for all cylinders (100% p_{max} +/- 3 bar). Fix the VIT-racks in these positions (tie, or clamp, etc.). Note the individual VIT-rack indexes.
- 2) Then reduce the engine load to the break-point *, and again adjust the VIT-racks manually, until the p_{max} values are equal for all cylinders. Note again the VIT-indexes.

* **NB** For engines with fixed pitch propellers, the break-point is equal to approx. 78% load for MK I engines, and 85% for MK II engines (see sea-trial curves).

For engines with controllable pitch propellers (constant engine speed), the corresponding figures are approx 85%, and 90% load, respectively.

On new plants, where we have to calculate with the propeller becoming "heavier", it is advisable to set the break-point at a 2-3% higher load. This is in order to prevent an excessive "pressure-jump" ($p_{max}-p_{comp}$) when the plant becomes older, because the break-point will "wander downwards" the heavier the propeller becomes.

- 3) Remove the VIT-rack fixings.
- 4) Stop the engine and, if necessary (f.inst. in the case of worn pumps), move the fuel cams such that all VIT-index's have nearly the same values ($\pm 1/2$)**. See Appendix 1 for an example regarding setting of the cams.

** This is a practical guide for adjustment purposes. However, due to possible differences in injection system wear, larger values may be acceptable in service, as long as full-index is not obtained at the break-point, or zero index does not occur at overload.

- 5) Re-start the engine and run up to the break-point. Referring to Fig. 2, loosen the arm (B) and retighten it in such a position that the beam (A) touches the two supports (F_1) and (F_2).



- 6) Then check p_{max} level for all cylinders, and if necessary make collective adjustment (to 100% p_{max}) by moving the position sensor valve (D). To do this, loosen the bolts (G) and move the sensor valve by means of the adjusting screws (H). See also Fig. 7. Afterwards retighten the bolts (G).
- 7) Run the engine from the break-point up to 100% MCR, and check p_{max} again. If necessary, collectively readjust p_{max} by moving point (F1), until 100% $p_{max} = p_{max}$ at the break-point, see Fig. 7. After re-adjustment, p_{max} should be checked once more at the break-point, and at 100% MCR.

3.1 Non-return throttle valve: function, and adjustment:

A non-return throttle valve (***) is mounted in the control air line, between the position sensor valve and the position servos, see Fig. 6.

This valve has two main functions:

- 1) To prevent excessive combustion pressure during sudden load reductions in the upper load range (i.e. above the break-point), for example in rough sea conditions.
- 2) To avoid rapid fuel-rack oscillations from being transmitted to the VII-rack (i.e. to obtain a stable VII-rack, for instance in case of slight governor jiggling).

Before, or during, shop and sea trials, the non-return throttle valve is temporarily adjusted such that the trials can be conducted without inconvenience.

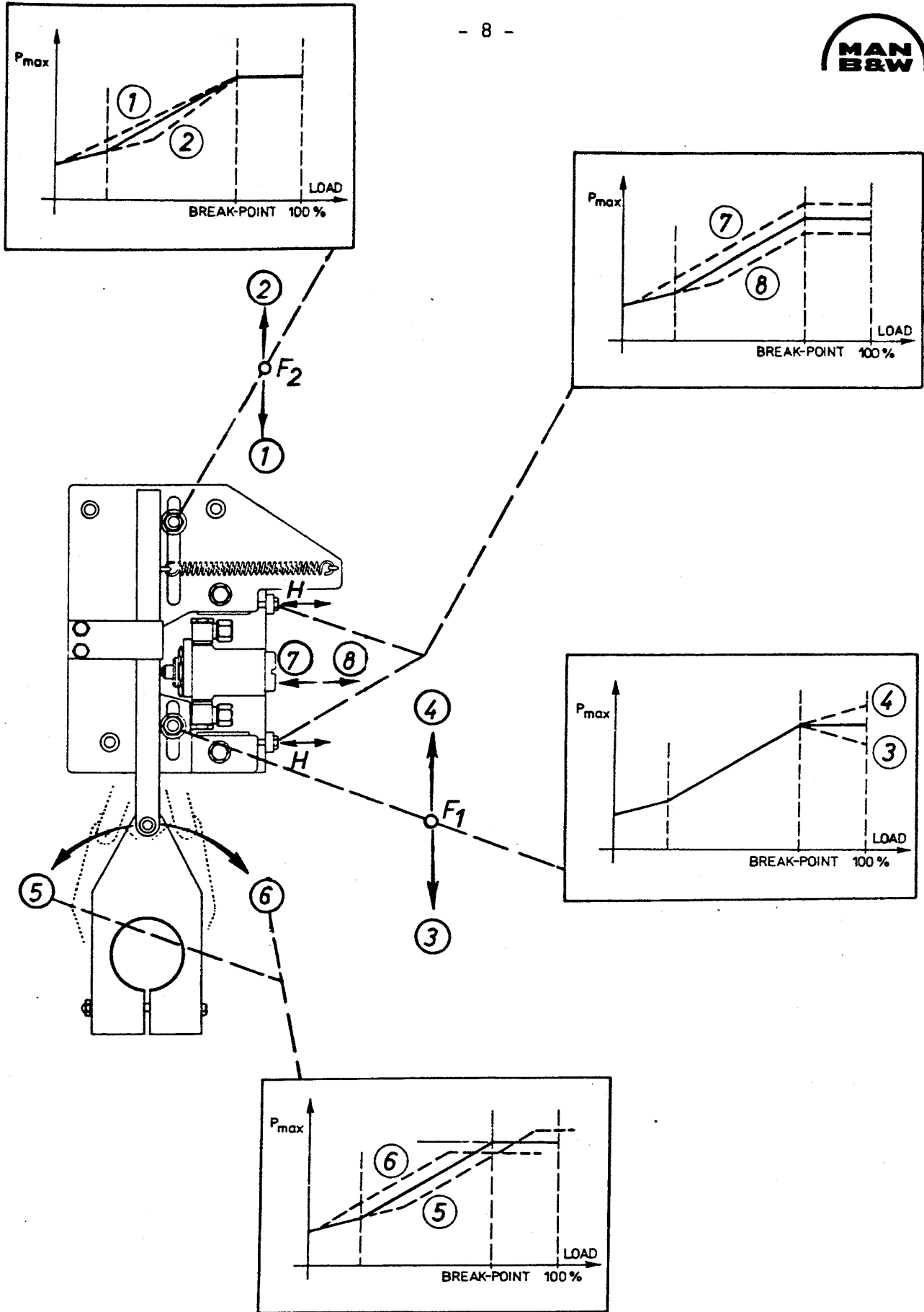
The initial adjustment (***) of the valve is carried out as follows: (this can be done with either stopped or running engine).

- a) The throttle screw is fully opened, i.e. max. anti-clockwise (= counter clock wise = ccw)
- b) By means of the handwheel on the emergency stand, adjust the fuel-rack position until the maximum control air pressure can be read on the pressure gauge (i.e. corresponding to the break-point pressure).
- c) The throttle screw is then turned towards the closed position (clockwise = cw) until the pressure starts dropping. At this point the screw is turned one revolution back (counter-clockwise = ccw).

NB If the position servos and piping have no leakages, it may prove possible to close the throttle screw completely, without observing any drop in pressure. Therefore, during the above adjustment, it may be necessary to introduce a small leakage at the position servo (i.e. loosen a pipe connection).

The final adjustment is completed during the maiden voyage.

In order to judge the setting and effectiveness, the following stability criterion should be used:



Please note, the super-VIT mechanism only operates at control air pressures greater than 0.5 bar.

Fig. 7 - SUMMARY OF ADJUSTMENT POSSIBILITIES



- during rough ~~sea~~ conditions, a rapid variation of +/- two (2) fuel index, should not influence the VIT-rack position.

If the VIT-rack position is influenced, readjustment must be carried out as indicated above.

***) NB: On some engines a simple throttle piece (non-adjustable) is fitted instead of an adjustable throttle valve. In such cases, the orifice hole will have been correctly dimensioned on testbed.

4. MAINTENANCE

Due to leakages or maladjustment in the VIT-regulating system, it may, in the course of time, be necessary for the crew to re-adjust the throttle valve setting. If, f.inst., the VIT is hunting, we recommend that the following is done:

- a) The throttle valve screw is opened fully (max. ccw).
- b) Then the setting is re-adjusted as described in section 3.1 above.
- c) The stability is then checked using the mentioned criterion.

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APPENDIX 1

FUEL CAM SETTINGExample:

Cyl.	VIT-index at break-point	VIT-index at 100% load	Average value	Required index after turning the cam	Difference between average and required index *)	Cam top-lift to be adjusted by the following (mm):
1	6	2	4	5	4-5 =-1	-1
2	8	4	6	5	6-5 =+1	+1
3	7	4	5.5	5	5.5-5 =+0.5	+0.5
4	6	1	3.5	5	3.5-5 =-1.5	-1.5
5	9	5	7	5	7-5 =+2	+2

NB Owing to differential pressure-areas, the pump barrel will tend to move upwards! Therefore, when reading VIT-indexes, the VIT-rack is to be pushed inwards.

*) Please note that for all engine types 1 (one) index increase corresponds to 1 (one) mm increase in top-lift. (increased top-lift = forward)