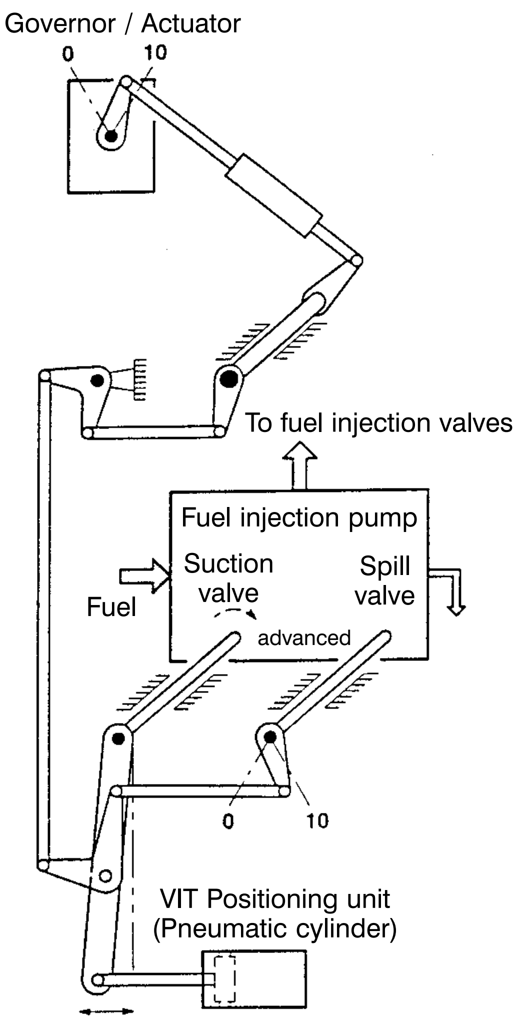
SULZER **RTA Engines**

Service Bulletin

RTA–53
12.06.2001

Technical Information to all Owners / Operators of Sulzer RTA Engines
(except RTA 38 and RTA 48)

Variable Injection Timing and Fuel Quality Setting



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28.79.71.40 Printed in Switzerlans

1. INTRODUCTION

In the seventies when fuel consumption gained more importance Sulzer introduced the so called **V**ariable **I**njection **T**iming and **F**uel **Q**uality **S**etting (VIT and FQS) system on its low speed two stroke engines.

The VIT and FQS system performs two main tasks. The VIT part is an automatic function that controls the injection begin depending on the actual engine load and cares for optimum part load fuel consumption. The FQS part is a manual adjustment that is meant to be used to match the injection timing to the quality of fuel used.

VIT and FQS have been introduced as standard on RTA engines at first in a mechanical and later in an electronic version. The latter is the only standard system for current RTA engines and will be the main subject of this Bulletin.

A retarded injection is one of the measures used on Sulzer RTA engines to comply with the International Maritime Organisation (IMO) NO_X emission regulations. The applied injection delay depends on engine type and rating and has been introduced in the DENIS-system as a new, load-independent parameter. Therefore the VIT system has gained considerable importance with the introduction of the engine tuning complying with the IMO NO_X (Oxides of nitrogen) emission regulations on the Sulzer RTA engines.

Due to the optimisation character of the VIT function an engine can run both with and without VIT and FQS function without any loss of operability. However, because of its proven beneficial effect on fuel consumption especially at part load it is advisable to have the VIT and FQS system always working during normal engine operation. All RTA engines have been designed for continuous VIT and FQS operation i.e. the use of VIT and FQS keeps the engine parameters well within safe limits. On the latest RTA engine designs complying with the IMO NO_X emission regulations, the range of FQS adjustment is limited so that NO_X emission limits are ensured with any setting of the FQS.

This Service Bulletin shall explain the VIT and FQS system in its different design versions and give some general advice on how to check the system and its correct function in order to guarantee maximum availability and thus benefit for the operators.

This Service Bulletin should be kept in a separate file in the control room. The respective pages or tables of the Service Bulletin with modifications to the Operating Manual, Maintenance Manual or Code Book should be copied and filed in the respective Manual or Book.

2. WORKING PRINCIPLE OF THE VIT AND FQS SYSTEM

The following explanation of the effect of the VIT and FQS is a general one. The diagrams shown give an idea about the principal relation between the relevant variables but may have a quite different shape depending on the type of VIT system and its adjustment.

2.1. Variable Injection Timing (VIT)

The VIT function is used for load-dependent adjustment of the combustion pressure according to Fig. 1.

With an increase in maximum combustion pressure at part load, which is the predominant engine operation range, fuel consumption is reduced. As there is a correlation between injection begin and maximum combustion pressure, the start of delivery of the fuel injection pump can be used as control signal for the combustion (please refer to Fig. 2). Advanced injection begin raises the maximum pressure.

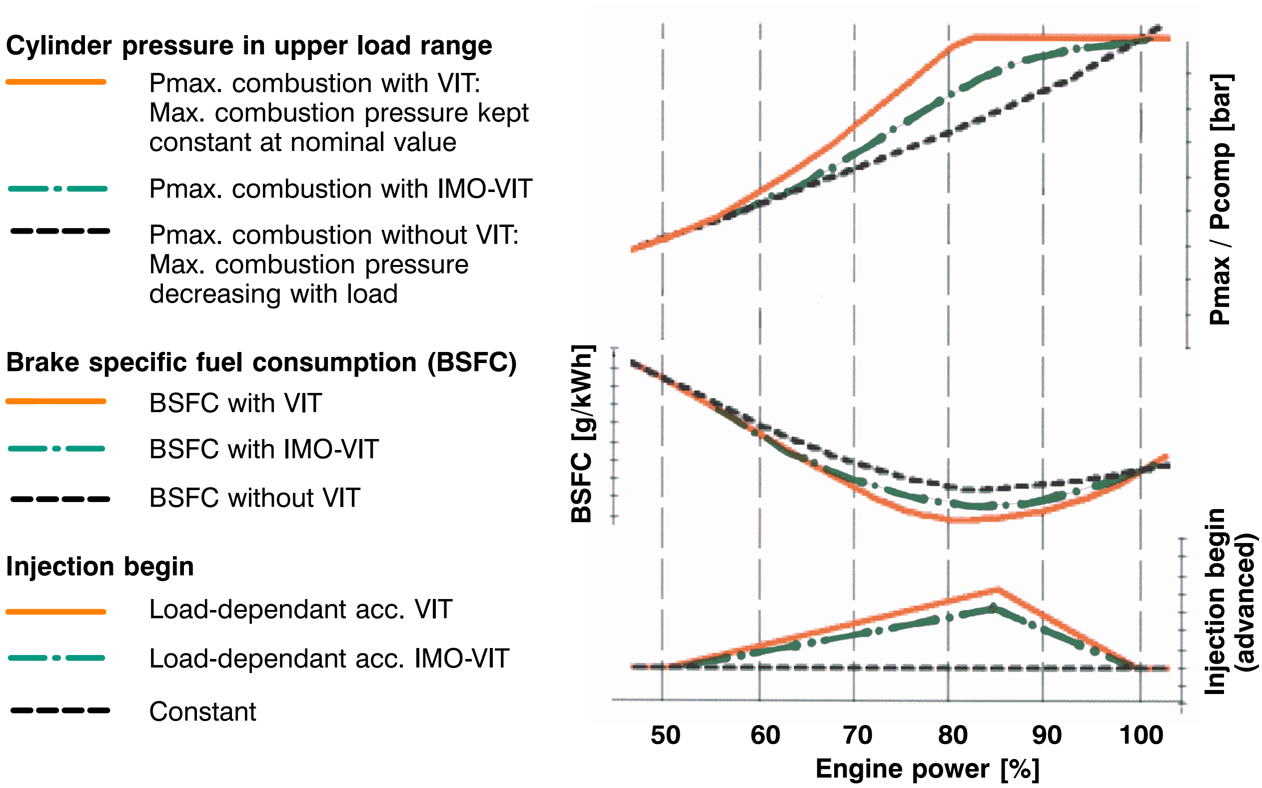


Fig. 1 General influence of the earlier fuel injection (VIT) to the combustion pressure and specific fuel consumption at part load operation

Without VIT

Injection begin fixed, determined by fuel injection pump setting
Result: Max. combustion pressure increasing with load

With VIT

Injection begin varying, determined by fuel injection pump setting and VIT value
Result: Max. combustion pressure kept constant at nominal value in upper load range

With IMO-VIT

Injection begin varying, determined by fuel injection pump setting and VIT value
Result: Max. combustion pressure decreasing with load according IMO-VIT curve

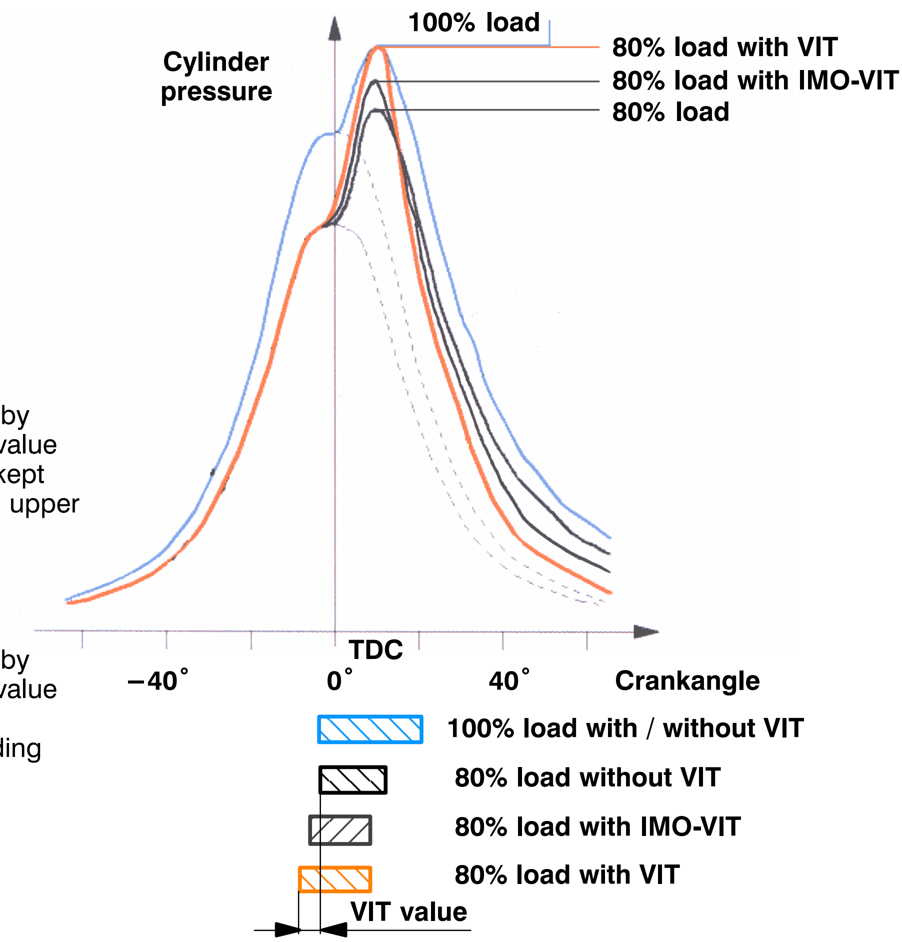


Fig. 2 Injection duration

2.2. Fuel Quality Setting (FQS)

With the manually adjustable Fuel Quality Setting (FQS), the engine operator can match the injection timing to the quality of fuel oil used. The ignition properties of Heavy Fuel Oil (HFO) can differ considerably from one fuel oil bunker to another. Fuel with poor ignition qualities results in lower firing pressures at the same injection begin. With a longer ignition delay the maximum pressure will decrease and this will have a negative influence on the specific fuel oil consumption. The difference in ignition delay can be compensated by applying a load-independent "offset" (=FQS value) to the delivery begin .

By changing the Fuel Quality Setting to advanced, i.e. earlier start of injection, the maximum pressure can be raised to the correct level and the specific fuel consumption will decrease. Fuels with a better ignition quality, i.e. less ignition delay, result in a higher maximum firing pressure and consequently the FQS has to be adjusted in the retard direction (lower / negative FQS value), i.e. later start of injection to avoid too high firing pressures. See also Fig. 3 below.

This adaptation has to be done by the operator whenever new fuel has been used. The combustion properties must be checked by means of indicator diagrams, whenever the Fuel Quality Setting adjustment has been changed, to ensure that maximum pressure and ignition ratio are kept within design limits (see also chapter 5 and 6.7 about piston running behaviour).

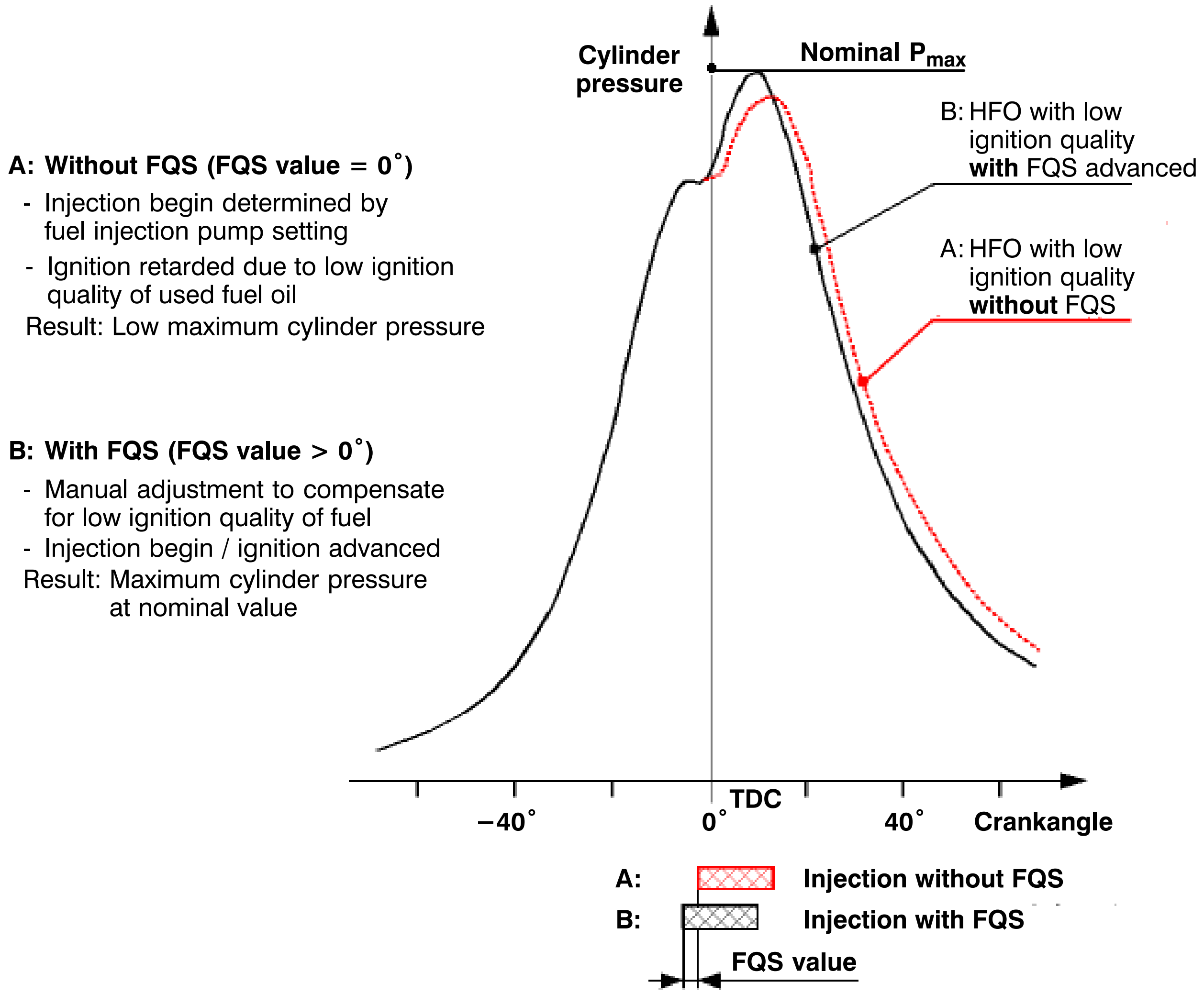


Fig. 3 Influence of FQS to the combustion pressure

3. VERSIONS OF THE VIT AND FQS DESIGN

The initial version of the VIT and FQS was a mechanical design (Fig. 4) using a cam to perform the load-dependent VIT function. FQS had to be set on a lever on the engine.

Obvious disadvantages of this mechanical arrangement were the mechanical limitations on the cam shape and the fact that any movement of the fuel regulating linkage was directly transferred to the VIT and FQS without any damping resulting in cam damages.

With the introduction of the electronically controlled VIT and FQS a clear improvement in this respect was achieved. The injection timing is now controlled by the position of a pneumatic cylinder that follows the control signal of the electronic control unit. By using digital control systems almost any shape of VIT curve is possible and the movement of the pneumatic cylinder is dampened for a smooth action on the fuel regulating linkage.

The first version of the electronic VIT and FQS introduced in 1986 has been a direct equivalent to the mechanical one i.e. the injection timing is set directly and only in function of the position of the fuel regulating linkage (= load indicator signal LI).

This VIT and FQS system has been introduced to the RTA “-2 Series” engines first as an option and later as standard.

Todays standard of the electronic VIT and FQS system for all RTA engines is a further development of the first version. In this design the injection begin is calculated based on two input signals being measured; engine speed (n) and charge air pressure (p_{ch}). The charge air pressure represents the real engine output in a more direct way than the load indicator, whereas the engine speed takes into account the operating point of the engine. Both control signals result in much more accurate control of the maximum cylinder pressure especially when running off the nominal propeller curve.

Being today’s standard, this Service Bulletin covers in detail the electronic versions of VIT and FQS only.

Despite the differences in the various designs of the VIT and FQS, certain basic rules have to be paid attention to for optimum engine performance at minimum fuel consumption and maximum reliability.

Basic information on the VIT and FQS system and instructions on the adjustment of same are given in the Operating Manual.

The table overleaf shows the different VIT and FQS types available on each engine type and the respective relevant chapters of this Bulletin.

Grp.	Engine Types	Control System	VIT and FQS Type	Relevant Chapter in this Bulletin	Remarks
1	RTA 58, RTA 68, RTA 76, RTA 84 RTA 52, RTA 62, RTA 72 RTA 84M, RTA 84C	SC [1] SBC [2] EC [3]	mechanical VIT and FQS	**4**	One VIT standard only Early engine designs before introduction of DENIS-1
2	RTA 84 RTA 52, RTA 62, RTA 72 RTA 84M, RTA 84C	DENIS-1 [4]	mechanical VIT and FQS electronic VIT and FQS, VIT=f(LI)	**4** **5.2**	mechanical VIT standard electronic VIT option
3	RTA 52U, RTA 62U, RTA 72U RTA 84C, RTA 84CU	DENIS-1	electronic VIT and FQS, VIT = f (LI) electronic VIT and FQS, VIT = f (n, p_{ch}) electronic VIT and FQS, VIT = f (n, p_{ch}) IMO tuning	**5.2** **5.3** **5.4**	Introduction of VIT =f (n, p_{ch}) according to availability in control system (>=1997)
4	RTA 84T, RTA 84T-B, RTA 84T-D	DENIS-5	electronic VIT and FQS, VIT = f (n, p_{ch}) with enlarged operating range electronic VIT and FQS, VIT = f (n, p_{ch}) IMO tuning enlarged operating range	**5.3** **5.4**	VIT acts together with VEC (Variable Exhaust Closing)
5	RTA 48T, RTA 48T-B RTA 58T, RTA 58T-B RTA 68T-B RTA 96C, RTA 96C-B RTA 52U-B, RTA 62U-B RTA 72U-B	DENIS-6	electronic VIT and FQS, VIT = f (n, p_{ch}) electronic VIT and FQS, VIT = f (n, p_{ch}) IMO tuning	**5.3** **5.4**	

Table 1

1) SC means **S**tandard **C**ontrol (without bridge control)
2) SBC means **S**ulzer **B**ridge **C**ontrol
3) EC means **E**lectrical Bridge **C**ontrol
4) DENIS-1 means **D**iesel **E**ngine Co**N**trol and Opt**I**mizing **S**pecification and the digit stands for the development status

4. MECHANICALLY CONTROLLED VIT AND FQS

Fig. 4 shows the principals of the mechanically controlled VIT and FQS for reference.

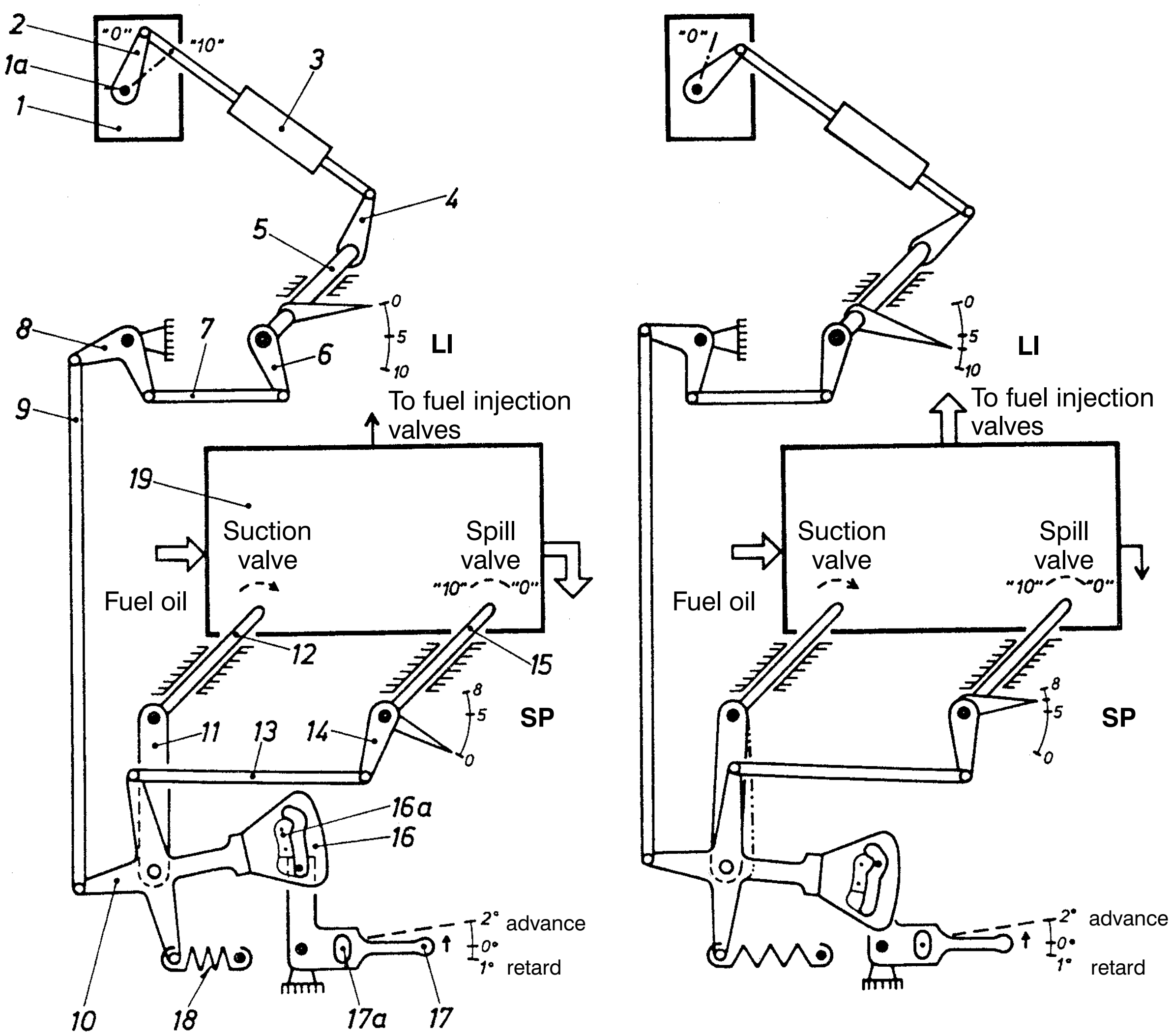


Fig. 4 Fuel Pump Regulating Linkage with Mechanically Controlled VIT and FQS in LI Position "0" and "7"

Index to Fig. 4

1	Speed governor
1a	Governor output shaft
2	Lever
3	Air cylinder
4	Lever
5	Intermediate regulating shaft
6	Lever
7	Adjustable rod
8	Dog lever
9	Adjustable rod
10	Dog lever
11	Suction valve regulating lever
12	Eccentric shaft for operating suction valves
13	Adjustable rod
14	Lever
15	Eccentric shaft for operating spill valves
16	Profile segment
16a	VIT cam
17	Setting lever for start of injection (FQS)
17a	Locking pin
18	Tension spring
19	Fuel injection pump
LI	Load indicator
SP	Setting scale

5. ELECTRONICALLY CONTROLLED VIT AND FQS

5.1. General

All electronic versions of VIT and FQS consists of two parts:

A: The logical control circuit is calculating the required injection timing based on the control signal used in the respective version of VIT and FQS.
These control functions are integrated into the main engine remote control system.

B: A pneumatic cylinder is used to position the eccentric shafts of the suction and spill valves resulting in the desired injection timing.

5.1.1. Control Circuit

The control logic calculates the required actuator position in accordance with its input signals (load indicator signal LI or engine speed n and charge air pressure p_{ch}, depending on version). With this position value as setpoint the control system gives extend and retract commands to the solenoid valves until the pneumatic cylinder has reached its correct position as detected by the feedback potentiometer.

The functions of the control circuit depend on the version applied and are described in the respective chapters 5.2 – 5.4.

5.1.2. Arrangement of Fuel Regulating Linkage

(Please refer to Fig. 5)

The position of the output lever of the speed control system (= governor) defines the quantity of fuel injected by the fuel injection pumps. It sets the position only of the spill valves eccentric shaft relative to the position of the suction valves eccentric shaft and thus defines the duration of the injection.

The actuator of the VIT and FQS system Fig. 5 (Item 18) works on **both** the eccentric shafts of the spill and suction valves of the fuel injection pumps and thus advances or retards the injection.

The mechanical arrangement of the pneumatic cylinder may include mechanical stops (see Fig. 9 Item 25 and 25a) to move the cylinder manually in case of a failure in the automatic positioning system.

Each positioning unit has a distance sleeve (Item 22) that allows the VIT and FQS to be fixed in its neutral position. The exact mechanical arrangement differs for the various executions. Therefore refer to your Operating Manual for detailed information.

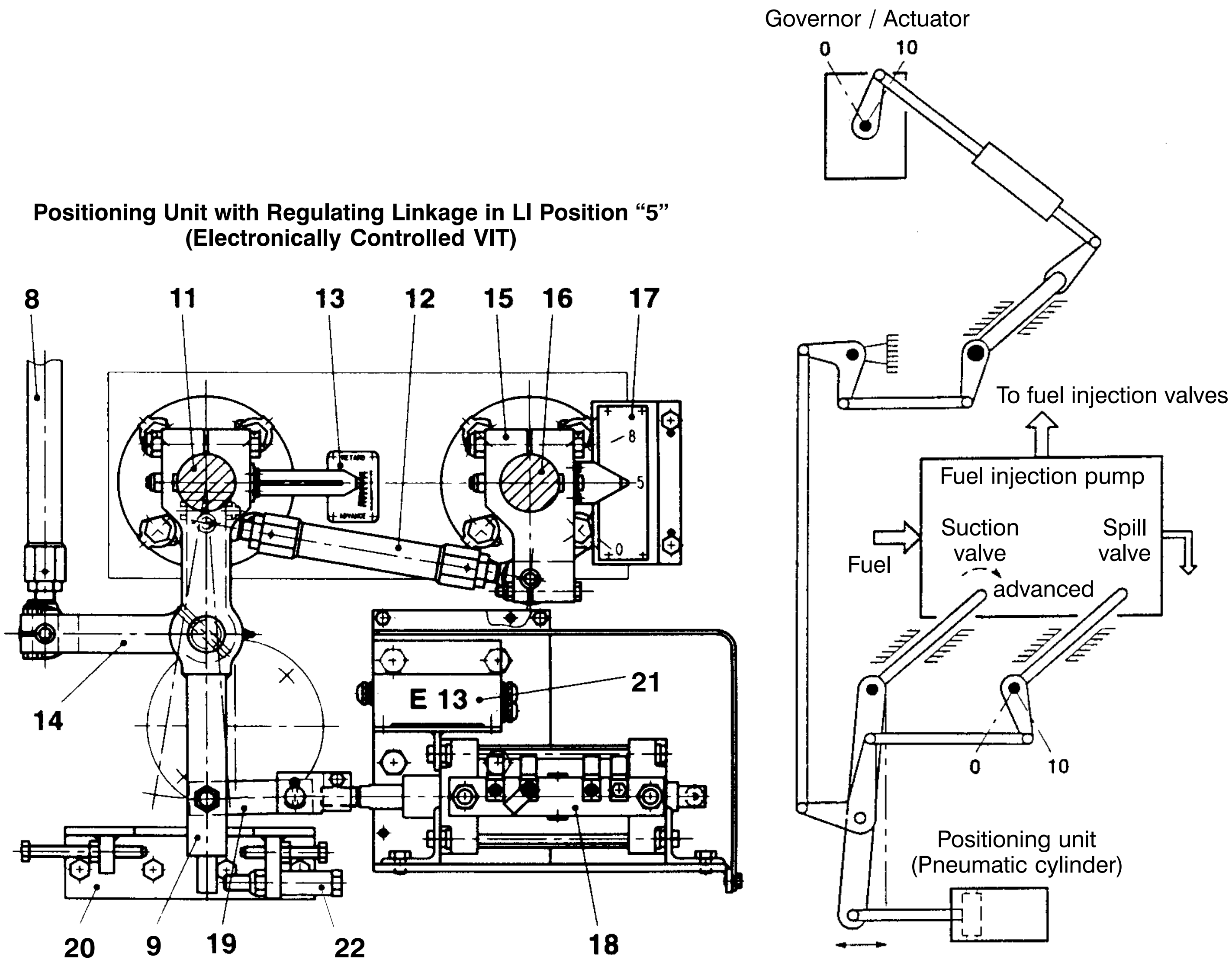


Fig. 5 Fuel Pump Regulating Linkage with Electronically Controlled VIT

Index to Fig. 5

8 Vertical rod
9 Suction valve regulating lever
11 Eccentric shaft for suction valves
12 Rod for eccentric shaft 16
13 VIT indicator
14 Diverting lever for VIT
15 Spill valve regulating lever
16 Eccentric shaft for spill valves
17 Setting plate (LI position)
18 Positioning unit
19 Connecting strap
20 Suction valve regulating lever blocking unit (LI position “0”)
21 Terminal box E 13 (RTA 62U)
22 Distance sleeve (Tool)

5.2. Electronic VIT and FQS

VIT = f (LI)

(Please refer to Fig. 6)

The first serial version of the electronic VIT and FQS has been a direct equivalent to the mechanical one, i.e. the injection timing is set depending only on the load indicator position (LI).

For the engine types to which this version of electronic VIT and FQS was applied please refer to Table 1. It was applied to engines of group 2 as an option and as standard to the engines of group 3 until about 1997.

The function of the control logic can be seen from Fig. 6.

The resulting injection timing is the sum of VIT angle and the set FQS angle. In case of switching off the VIT function the positioner will follow the the FQS setting only.

The so called heavy sea filter will smoothen the actuator movement at fast load indicator movements caused, for example, by heavy sea.

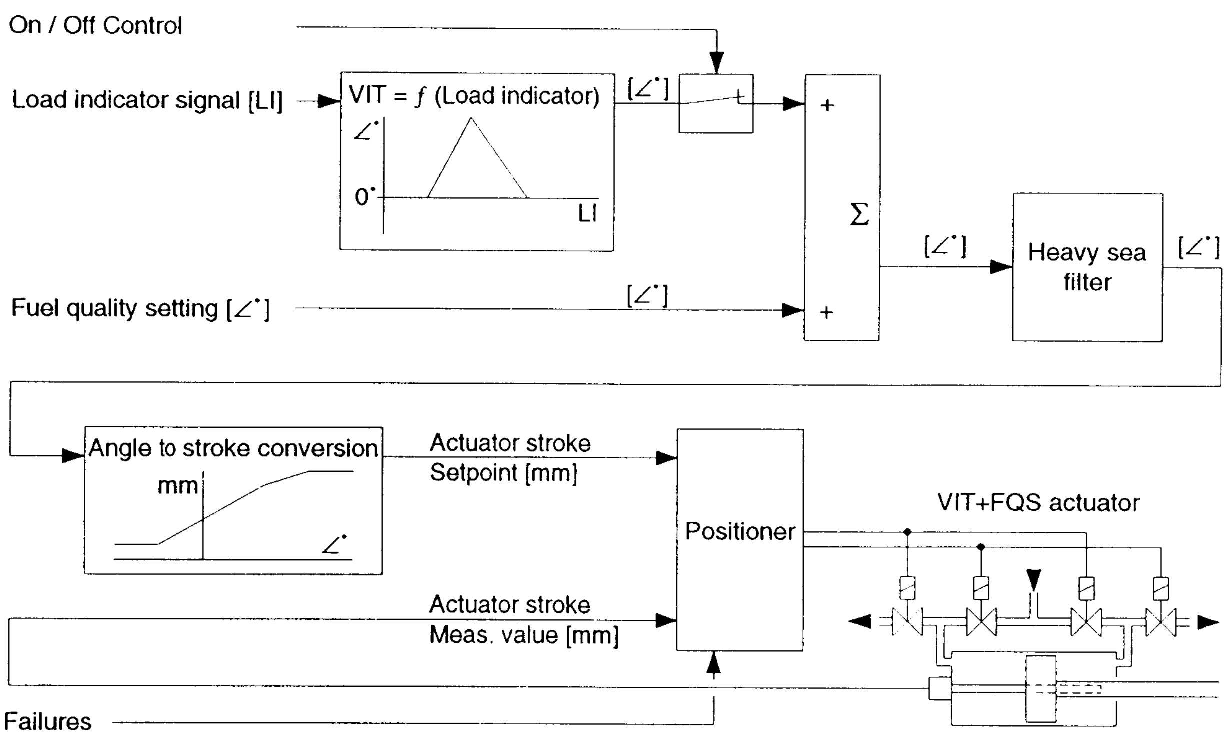


Fig. 6 Simplified Block Diagram for VIT and FQS VIT = f (LI)

5.3. Electronic VIT and FQS VIT = f (n, p_{ch})

(Please refer to Fig. 7)

An improved version uses measured engine speed (**n**) and actual charge air pressure (**p_{ch}**) as control signals for the VIT. By taking into account both signals at the same time this VIT version can better adapt to real engine load conditions off the nominal propeller curve due to, for example, sea margin and engine load changes generated for instance by fouling of the ship's hull or by weather conditions.

For the engine types to which this version of electronic VIT and FQS was applied please refer to Table 1. A VIT function controlled by engine speed and charge air pressure was first introduced on the RTA 84T engine, applied as standard to all engines of group 4 and 5 and also applied to the engines of group 3 starting in 1997. The time frame for introduction of this version of VIT and FQS to engines of group 3 depends on the maker of the engine remote control system. In case of doubt please consult your remote control documentation or contact the respective maker.

For engines of group 3 (DENIS-1) and 5 (DENIS-6) the power range in which the maximum combustion pressure is kept close to the nominal value from 85% to 100%.
For engines of group 4 (DENIS-5) this range is from 65% to 100%. In order to keep the ratio $P_{max\ Combustion}$ / $P_{Compression\ at\ TDC}$ within its limits the VEC (Variable Exhaust Closing) is applied to these engine types. The VEC increases compression pressure in the lower power range resulting in lower $P_{max\ Combustion}$ / $P_{Compression\ at\ TDC}$ ratios.

The function of the control logic can be seen from Fig. 7.

The injection timing defined by the VIT function is basically the sum of two independent signals (VIT signal “A” and VIT signal “B”). The VIT signal “A” is a VIT angle defined in function of the charge air pressure and the VIT signal “B” is defined in function of the measured engine speed.
When running on the nominal propeller curve the resulting VIT curve (VIT “A” + VIT “B” signal over engine power) has a similar shape to that shown in Fig. 1. In any other operating condition the resulting VIT angle is adjusted in an appropriate way to still achieve maximum cylinder pressure over engine power as shown in Fig. 1.
A manually selectable “Low NO_X Mode” results in a retarded injection over a large power range achieving reduced NO_X emissions, for example to meet local regulations / restrictions. This mode is not needed for IMO-tuned engines to comply with the IMO NO_X regulation.
In case of switching off the VIT function the VIT actuator will take a position defined by the value of the parameter “VIT off Position” (typically set to zero degrees) and the FQS setting.

The so-called heavy sea filter will smoothen the actuator movement at fast load indicator movements caused, for example, by heavy sea.

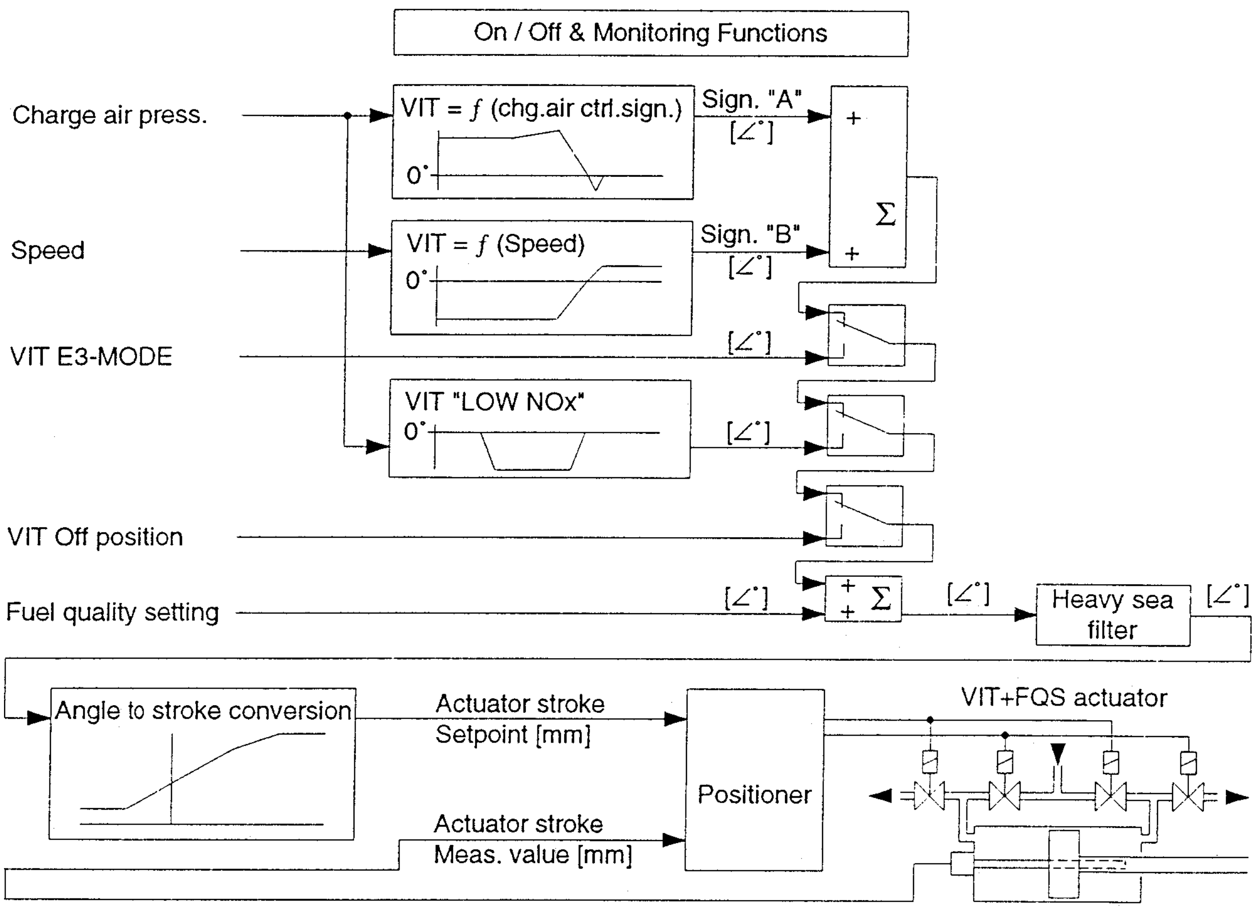


Fig. 7 **Simplified Block Diagram for VIT and FQS**
VIT = f (n, p_{ch})

5.4. Electronic VIT and FQS
VIT = f (n, p_{ch}) IMO
(Please refer to Fig. 8)

The introduction of the engine tuning to comply with the IMO NO_X emission regulations made some changes to the VIT control circuit and its settings necessary.
The VIT for IMO tuning is defined on the basis of the in the meantime well proven VIT version using measured engine speed (**n**) and actual charge air pressure (**p_{ch}**) as control signals as described in chapter 5.3.

For the engine types to which this version of electronic VIT and FQS is applied, please refer to Table 1. An IMO-tuned VIT function is available for all engines already using the VIT controlled by engine speed and charge air pressure i.e. engines of group 3, 4 and 5. Any particular engine uses this VIT version when specified as “IMO 2000 compliant”.
In case of doubt please consult your remote control documentation or contact the respective maker.

For IMO-tuned engines of group 3 (DENIS-1), group 4 (DENIS-5) and group 5 (DENIS-6) a ’smoother’ VIT is applied, leading to approximately 4 – 5 bar lower firing pressure at 85% than at 100% load.
For IMO-tuned engines of group 4 (DENIS-5) the VEC has been modified to later exhaust valve closing timings (’smooth’ VEC).

The functions of the control logic can be seen from Fig. 8.

In addition to the functions according to Fig. 7 a parameter “IT OFS” is added to the calculated injection angle. This parameter has been introduced for the basic adjustment of maximum combustion pressure and the additional delay (if applied) for NO_X reduction (reduced maximum combustion pressure). This offset parameter “IT OFS” depends on engine type and rating. The value is adjusted during the engine tuning on the testbed and recorded in the Technical File. It must never be altered later on.

Another consequence of the IMO Tuning is the parameter “IT AST”. When running in the astern direction, the injection timing is keep constant on the “IT AST” value defined individually for each engine depending on type and rating.

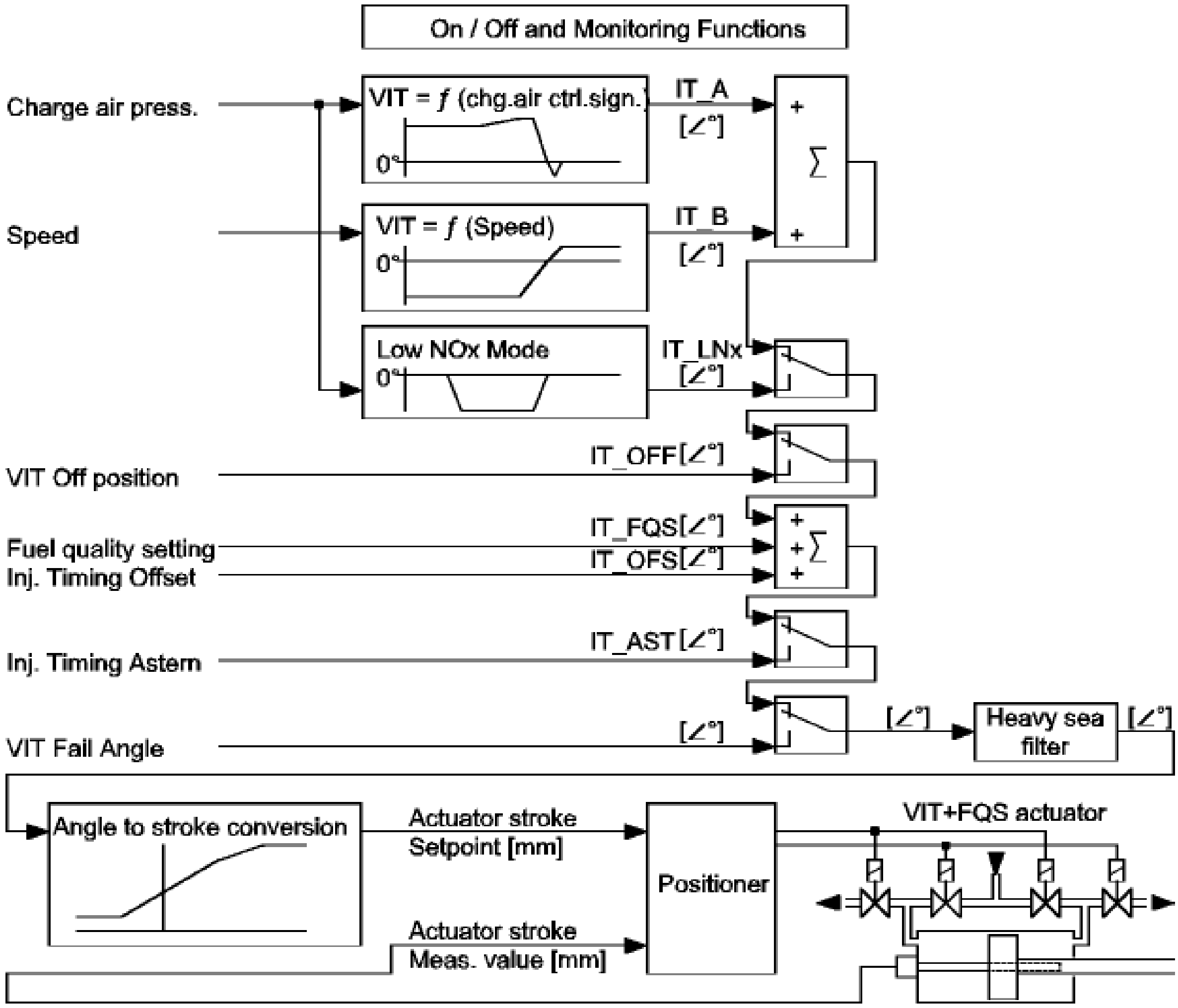


Fig. 8 Simplified Block Diagram for VIT and FQS
VIT = f (n, p_{ch}) IMO Tuned

6. OPERATIONAL ASPECTS

Basically the VIT and FQS system does not need any special attention or operation. Under normal engine running conditions the VIT and FQS system should always remain switched on.

From time to time especially after using a new fuel quality, the FQS setting should be checked for its correct value by measurements of the cylinder peak pressures and adjusted accordingly if necessary.

The correct parameters for the electronic VIT are determined and documented individually for each engine during shop trial following the engine designer's commissioning instructions and must not be changed unless instructed to do so.

The following sections in this chapter will focus on maintenance work and special running conditions.

It has to be emphasised that this Bulletin cannot give either a complete check-list nor a remedy for operational shortcomings of the VIT system, if troubles are related to deviations from basic engine performance as documented by the shop trial report. Only some basic checks which can be carried out even by non-specialists and directly related to the VIT and FQS equipment are highlighted here.

Whenever you are in doubt about VIT / FQS operation please contact **Wärtsilä Switzerland Ltd** Fax No. +41 52 262 07 16 **or any of our Network Companies**.

6.1. Setting of Regulating Linkage and Fuel Injection Pumps

Setting of regulating linkage and fuel injection pumps has been carried out prior to the shop trial, but if main parts of the fuel injection pumps or regulating linkage have been exchanged the following checks should be carried out:

6.1.1. Checking of Regulating Linkage

Check of correspondence between load indicator position read on the setting plate (see Fig. 5 Item 17), the load indicator on the local manoeuvering stand and the remote control system in the control room at VIT and FQS set to position "0". Deviations indicate that the setting of the regulating linkage is no longer according to specification and has to be corrected before any other action on the fuel injection pumps (Timing) is taken.

Please refer in this context to the separate Service Bulletin "Fuel Injection Pump Regulating Linkage".

6.1.2. Fuel injection Pumps

The maximum admissible deviation between the biggest and smallest effective delivery stroke on individual cylinders is 0.2mm, and the deviation of the effective delivery stroke to the value in the original timing records should not exceed ± 0.1mm.

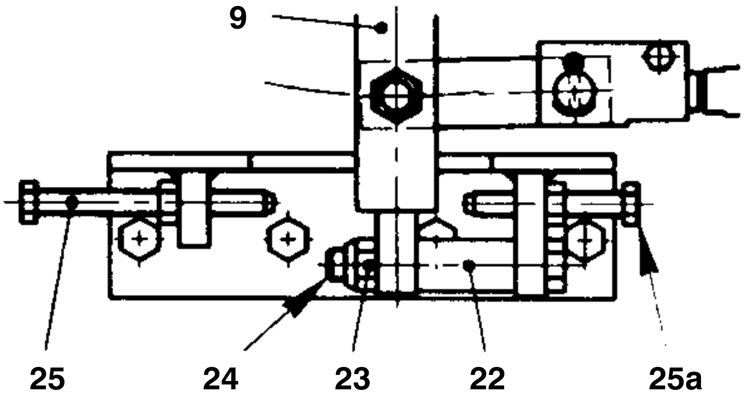
The start of injection (∢ before or after **T**op **D**ead **C**entre) of a fuel injection pump may only be altered by shifting the fuel cams and not by re-setting the regulating tappets of the suction valves. The deviation to the original timing record shall not exceed ± 0.3°.

For IMO-tuned engines the suction valve closing timing (injection delivery begin) should be as close as possible to the values reported in the Technical File (List of NO_X relevant components and setting). The mean value averaged over all cylinders should be within a tolerance of 0.0 to −0.3° Crankangle (Note: Only later injection is allowed). Each cylinder itself can be adjusted within a tolerance of +0.2° to −0.5° Crankangle. Please note that the suction valve closing timing is a NO_X relevant setting for IMO compliant engines and might be checked on board by surveyors.

As the VIT affects all fuel injection pumps uniformly it is obvious that deviations in the settings from pump to pump can not be compensated by the VIT.

6.2. VIT Actuator Setting

Check of the actuator stroke at VIT position “0” mechanically by inserting the distance sleeve (see Fig. 9 Item 22) between suction valve regulating lever and blocking unit (see also Fig. 9 or Operating Manual). The distance sleeve fixes the neutral position of the VIT leverage without having to move the actuator. The position of the regulating linkage is indicated on the setting plate (see Fig. 5 Item 17) and corresponds now to “0”.



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9	Suction valve regulating lever
22	Distance sleeve (Tool)
23	Stop nut
24	Screw for fitting distance sleeve
25	Setting screw
25a	Setting screw

Fig. 9 Suction Valve Regulating Lever Blocking Unit

Check of the actuator stroke at VIT position”0” electrically at the remote control system (RCS) in the control room. The value shown on the RCS should correspond to the documentation of the remote control manufacturer.

Move the VIT actuator to maximum advanced position (e.g. 5° advanced) and maximum retarded position (e.g. 2° retarded for engines with DENIS-1 or 5° retarded for engines with DENIS-6) respectively and read the load indicator position on the setting plate (see Fig. 5 Item 17). Further check the stroke of the actuator at the remote control system and compare with the manufacturer’s documentation.

6.3. Checking of the Control Performance for VIT= f (LI)

The values of the load indicator position, the VIT angle and the FQS value can be read during engine operation. These values shall be compared with the values of the VIT and FQS setting protocol supplied by the remote control manufacturer.

6.4. Checking of the Control Performance for VIT= f (p_{ch}, n)

In this version the VIT setting depends on both charge air pressure and engine speed. The values of the charge air pressure transducers (2 values) at the remote control system and the reading on the charge air pressure gauge on the local manoeuvring stand should be taken and compared during engine operation. These values can be further compared with the values of the VIT and FQS setting protocol supplied by the remote control manufacturer. The difference between the two signals from the pressure transmitters should be less than 0.1 bar otherwise an alarm should be given.

6.5. Special Engine Running Conditions

As mentioned above, under normal engine operating conditions the VIT and FQS system should always be in operation. However, there are some limited operating conditions at which the VIT should be deactivated for reducing the maximum combustion pressure of the engine. These conditions are given in the following chapters.

6.5.1. Running-in of new Cylinder Liners and / or Piston Rings

For running-in of newly fitted cylinder liners the VIT and FQS should be turned off for 50−200 running hours (see Operating Instructions and Service Bulletin “Running-in of Cylinder Liners and Piston Rings”). When the VIT system is operative, it is recommended not to install the distance sleeve (Fig. 9 Item 22) in order to be able to electronically set a FQS value according to the fuel oil quality used and the maximum admissible ignition ratio $P_{max\ Combustion}$ / $P_{Compression\ at\ TDC}$.

When the VIT and FQS is switched off the VIT actuator position is defined by the parameter “VIT off Position” and the FQS value. With “VIT off Position” set to “0” (should always remain “0” with the engine in operation) the VIT actuator will keep the position set by the FQS.

6.5.2. Failure of VIT

Upon failure of the VIT system the combustion peak pressure can not be controlled by the pneumatic actuator any longer. The distance sleeve (Fig. 9 Item 22) has to be installed to fix the neutral position of VIT / FQS.

6.6. FQS Setting

Before the FQS is adjusted an exact firing pressure measurement is required. Further it must be established whether the firing pressure alteration is actually due to a fuel oil quality change. Alteration of firing pressure due to fouling / restriction in the air / gas flow or other causes should not be compensated with the FQS adjustment.

6.7. Ignition Ratio

The ratio $P_{max\ Combustion}$ / $P_{Compression\ at\ TDC}$ is an important parameter influencing the performance of the piston rings, fuel economy and emissions (which is becoming more and more important). There is no physical or thermodynamical definition for optimum or maximum ratio of $P_{max\ Combustion}$ / $P_{Compression\ at\ TDC}$. Based on service experience and shop trial results the ignition ratio for our engines is optimised in such a way that long **T**ime **B**etween **O**verhauls (TBO) as well as low fuel consumption are achieved. Our RTA engines are tuned so that $P_{max\ Combustion}$ / $P_{Compression\ at\ TDC}$ at 100% load will be 1.2 which results in approximately 1.5 at part load.
For IMO-tuned RTA engines the firing ratio at 100% load results in 0.90 to 1.25, depending on engine type and rating. At part load the difference between firing pressure ($P_{max\ Combustion}$) and pressure at start of combustion ($P_{Ignition}$) must not exceed 40 bar.

These ratios can vary from engine to engine due to rating, scavenging air pressure and injection timing. In service, as a guide line, a pressure increase ($P_{Start\ of\ Combustion} \rightarrow P_{max\ Combustion}$) higher than 40−45 bar must be avoided, due to increasing risk of piston ring collapse or breakage due to material fatigue. In addition to the above, care should be taken that the ignition ratio as well as the maximum pressure should not exceed the values from the shop trial (see shop trial results and diagrams of the engine).

7. SERVICE BULLETINS PUBLISHED FOR LARGE BORE RTA–TYPE ENGINES

We have so far published the following Service Bulletins which are valid for Large Bore RTA−Type Engines (RTA 48T to RTA 96C):

RTA−1	dated 01.03.88	**Recommendation Concerning Piston Running Behaviour**
RTA−2	dated 05.10.88	**Water Drain from Charge Air Receiver and Charge Air Temperature**
RTA−3.4	dated 30.03.98	**Fuel Injection Nozzles**
RTA−4	dated 20.11.89	**Oil Damping for Short Tie Rods**
RTA−8	dated 15.06.92	**RTA−Cylinder Liners and Reinforced Water Guide Jackets**
RTA−9	dated 20.07.92	**Cylinder Cover with Erosion / Corrosion Resistant Cladding**
RTA−10	dated 28.10.92	**RTA ”−8 Series” Engines / Piston Skirt in Two Parts**
RTA−11.2	dated 11.05.2001	**Fuel Injection Pump Regulating Linkage**
RTA−14	dated 30.11.93	**System Oil Care and Maintenance**
RTA−15	dated 10.02.94	**Elastic Studs on RTA-Type Engines**
RTA−16.1	dated 20.02.98	**Retrofit for Piston Rod Stuffing Boxes for RTA ”-8 Series” Engines**
RTA−17.1	dated 28.02.95	**Circulation Valve to Fuel Injection Valve**
RTA−18.1	dated 27.08.98	**Running-in of Cylinder Liners and Piston Rings**
RTA−19	dated 28.10.94	**Oil Supply Monitoring for Geislinger Torsional Vibration Damper**
RTA−20	dated 30.11.94	**Rotational Safety Studs for Roller Guide of Fuel Pump and Exhaust Valve Actuator**
RTA−21	dated 10.04.95	**Improvement of Starting Behaviour (For engines with DENIS−1 and DENIS−5 Control Systems only!)**
RTA−22.1	dated 28.11.96	**Waisted Bolts for Piston Crown Spraying Plate of RTA 84C, 84CU, 84M and 84T Type Engines**
RTA−24.2	dated 18.05.99	**VTR..4 Turbochargers After Sales Service Information issued by ABB**
RTA−26	dated 03.01.96	**Loss of Material on Piston Crowns due to High Temperature Corrosion and Erosion (Watercooled Pistons)**
RTA−27	dated 26.04.96	**Plastic Water Separator**
RTA−28	dated 31.05.96	**Improvement of the Engine Control System**
RTA−29	dated 21.10.96	**Improved Oil Supply to the Integrated Axial Detuner equipped with Internal Oil Supply Line**
RTA−30	dated 27.11.96	**Improvement of starting behaviour on RTA engines equipped with Type PGA200 and PGA EG200 Woodward Governors**
RTA−31	dated 23.01.97	**Alphabetical Index of Topics of Service Bulletins**
RTA−33	dated 11.04.97	**Crank Pin Bearing Shell**
RTA−34	dated 28.11.97	**Fuel Injection System Modification and Maintenance**
RTA−35.1	dated 07.06.2001	**Retrofit for Piston Rod Stuffing Boxes for RTA ”-2 and -2U Series” Engines**
RTA−36.1	dated 08.06.2001	**Reconditioning of Piston Rods of RTA “-2 Series” Engines**
RTA−37.1	dated 11.06.2001	**Reconditioning of Piston Rods of RTA “-8 Series” Engines**
RTA−38	dated 26.02.98	**Piston Crown Loss of Material on Combustion Side**
RTA−39	dated 31.03.98	**Overhaul and Reconditioning of Pistons**
RTA−42	dated 25.09.98	**Templates for Exhaust Valve Seat and Spindle**
RTA−43	dated 20.01.99	**Piston Rings**
RTA−44	dated 26.02.99	**Tightening Instructions for the Plunger Guide Nipple**
RTA−45	dated 03.06.99	**Tightening Instructions for Screws and Waisted Studs**
RTA−46	dated 17.06.99	**Cracks in Columns**
RTA−47	dated 28.06.99	**Draining of Fuel Oil Pipes; Modification to Shut-off Valves of Fuel Pipes and Drain Plug of Fuel Pump Block**
RTA−48	dated 20.09.99	**Instruction for Replacement of NO_x Relevant Components on IMO Compliant Sulzer RTA Engines**
RTA−49	dated 08.10.99	**Gearing for Auxiliary Drives Z 42800**
RTA−50	dated 10.01.2000	**Leakage Oil Collector in Air Spring System**
RTA−51	dated 21.08.2000	**Deflagration in Engine Scavenge System and Exhaust Manifold**
RTA−52	dated 22.09.2000	**Water Separator on RTA − Type Engines**
RTA−53	dated 12.06.2001	**Variable Injection Timing and Fuel Quality Setting**

Should you not be in possession of the above mentioned documentation suitable for your plant, kindly contact your local Wärtsilä representative for your copy.