Instruction book for
Air dryers

FD7, FD16, FD30, FD40, FD60, FD80, FD100, FD120, FD160 and FD210

From following serial numbers onwards:

FD7/16:	AIQ 108 800
FD30/40/60:	AIQ 114 800
FD80:	AIQ 105 000
FD100:	AIQ 105 500
FD120:	AIQ 105 800
FD160:	AIQ 103 301
FD210:	AIQ 103 801

Registration code
Collection: APC FD
Tab: 38
Sequence: 999

Replaces
No. 2920 1187 02

This instruction book meets the requirements for instructions specified by the machinery directive 89/392/EEC and is valid for CE as well as non-CE labelled machines

Atlas Copco Industrial Air Division - B-2610 Wilrijk - Belgium

No. 2920 1187 03

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2920118703

This instruction book describes how to handle and operate the subject machine(s) to ensure safe operation, optimum working economy and long service life.

Read this book before putting the machine into operation to ensure correct handling, operation and proper maintenance from the beginning. The maintenance schedule contains a summary of the measures for keeping the dryer in good repair. The maintenance procedures are simple but must be carried out regularly.

Keep the book available for the operator(s) and make sure that the dryer is operated and that the maintenance actions are carried out according to the instructions. Record all operating data, maintenance work effected, etc. in an operator's logbook available from Atlas Copco. Follow all applicable safety precautions, amongst others those mentioned in this book.

Repair operations should be performed by trained personnel from Atlas Copco who can also be contacted if any further information is desired.

In all correspondence always mention the dryer type and the complete serial number, shown on the data plate.

For all specific data not mentioned in the text, consult sections "Maintenance" and "Principal data".

The company reserves the right to make changes without prior notice.

CONTENTS

1 LEADING PARTICULARS

1.1 General description

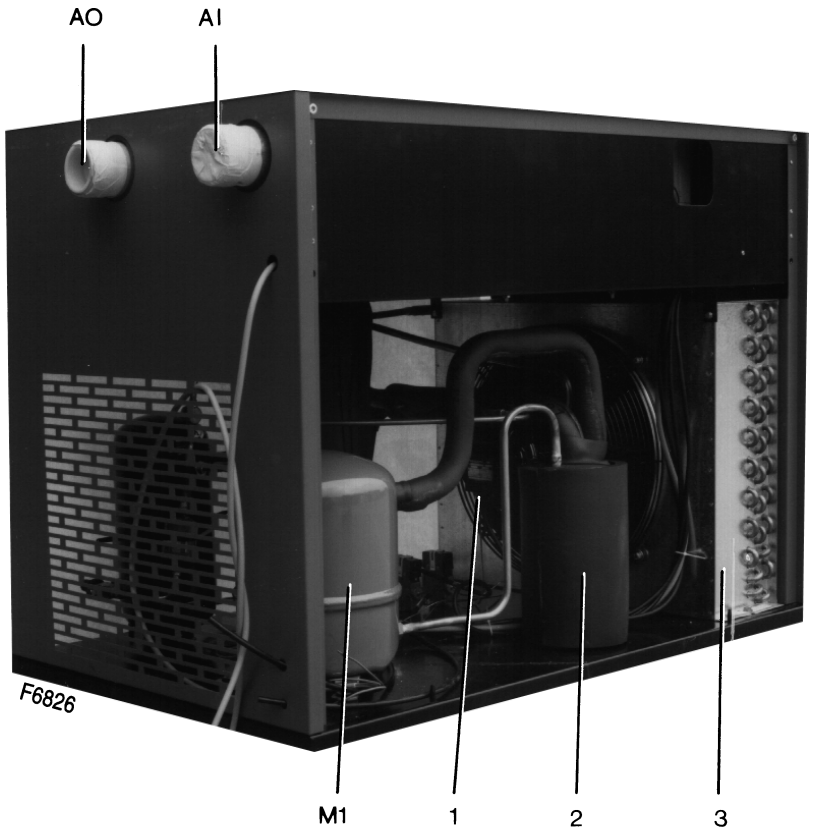
The FD air dryers remove moisture from compressed air by cooling the air to near freezing point. This causes water to condense. The condensate is automatically drained. The air is warmed up before leaving the dryer.

1.2 Air circuit (Fig. 3)

Compressed air enters heat exchanger (16) and is cooled by the outgoing, cold, dried air. Water in the incoming air starts to condense. The air then flows through heat exchanger/evaporator (15) where the refrigerant evaporates causing the air to be further cooled to close to the evaporating temperature of the refrigerant. More water in the air condenses. The cold air then flows through separator (3) where all the condensate is separated from the air. The condensate collects in condensate trap (4) and is automatically drained. The cold, dried air flows through heat exchanger (16), where it is warmed up by the incoming air to approx. 10 C (18 F) below the incoming air temperature. Condensation in the air net cannot occur unless the air is cooled to below the pressure dewpoint indicated by gauge (1).

M1. Refrigerant compressor
1. Control panel
2. Liquid separator
3. Condenser

Fig. 1. General view of FD210



AI. Wet air inlet
AO. Dry air outlet
M1. Refrigerant compressor
1. Fan
2. Liquid separator
3. Condenser

Fig. 2. Rear view of FD210

1.3 Refrigeration circuit (Fig. 3)

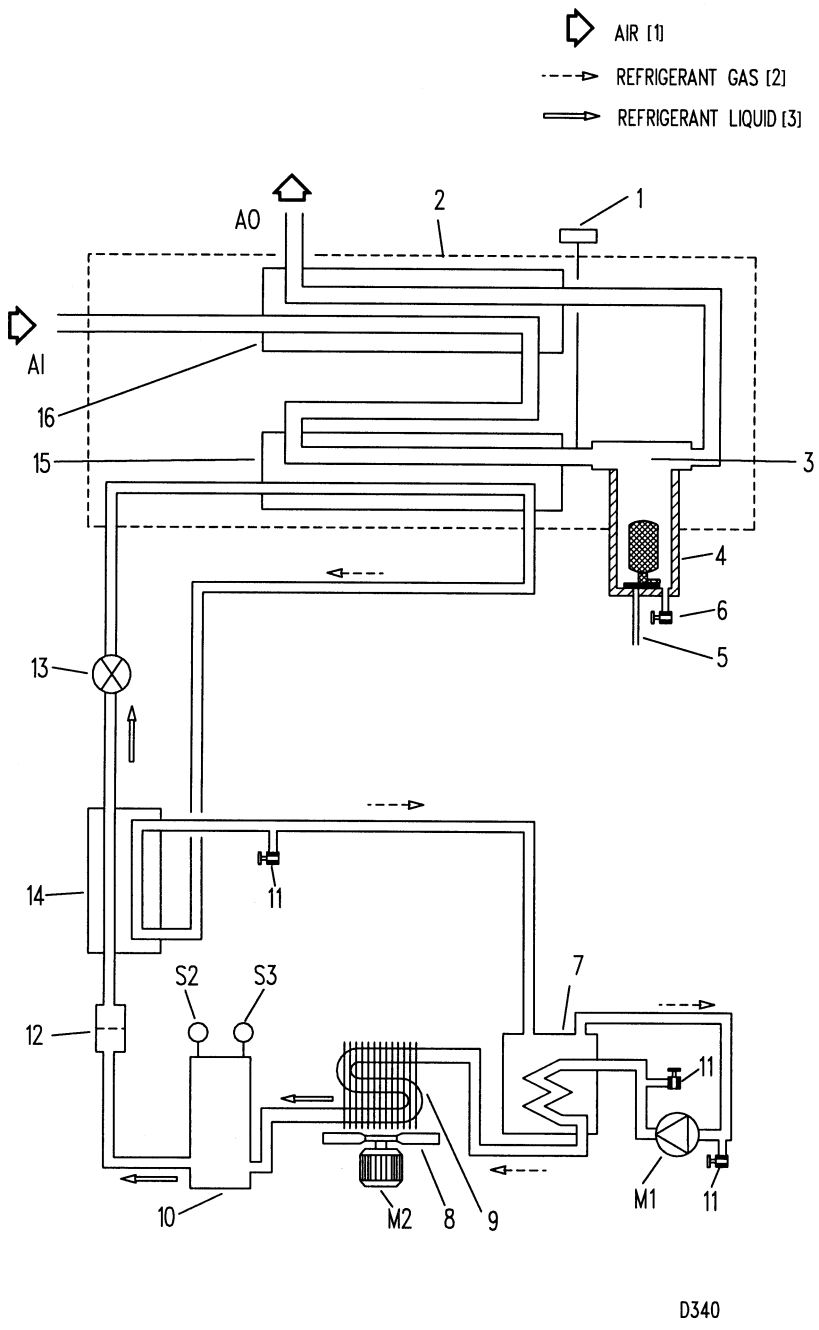
Compressor (M1) delivers hot, high-pressure refrigerant gas which flows via the coil of liquid separator (7) through condenser (9) where most of the refrigerant condenses. The cooled refrigerant then collects in receiver (10).

The liquid flows through liquid refrigerant dryer (12) to expansion valve (13) where it expands to evaporating pressure.

The refrigerant enters evaporator (15) where it withdraws heat from the compressed air by further evaporation. Dependent on the compressed air load, all, or almost all, refrigerant evaporates at constant pressure and temperature. The vapour refrigerant leaving evaporator (15) flows into liquid separator (7). The liquid separator prevents any droplets from entering compressor (M1) because warm refrigerant, leaving the compressor, flows through the liquid separator coil and evaporates the surrounding liquid. The refrigerant gas from liquid separator (7) is sucked in by the compressor.

1.4 Automatic regulation system (Fig. 3)

Expansion valve (13) maintains the evaporating temperature between 1 and -1 C (34 and 30 F); these are the approximate temperatures at zero and maximum air load respectively. At partial or no load, the excess cooling capacity is transferred in liquid separator (7). The condenser pressure must be kept as constant as possible to obtain stable operation of expansion valve (13). Therefore, fan control switch (S3) stops and starts cooling fan (M2).



AI.	Wet air inlet	3.	Condensate separator	10.	Liquid refrigerant receiver
AO.	Dry air outlet	4.	Condensate trap	11.	Refrigerant circuit access connections
M1.	Refrigerant compressor	5.	Automatic condensate drain hose	12.	Liquid refrigerant dryer
M2.	Condenser fan motor	6.	Manual condensate drain valve	13.	Refrigerant expansion valve
S2.	High pressure shut-down switch	7.	Liquid separator	14. **1)**	Refrigerant/refrigerant heat exchanger
S3.	Fan control switch	8.	Condenser cooling fan	15.	Air/refrigerant heat exchanger/evaporator
1.	Pressure dewpoint gauge	9.	Refrigerant condenser	16.	Air/air heat exchanger
2.	Insulating block				

1) Only on FD160-60 Hz, FD210-50 Hz and FD210-60 Hz.

Fig. 3. Air and refrigerant flow diagram

1.5 Electrical system (Figs. 4)

FD160 60 Hz and FD210 60 Hz dryers are 3-phase units, all other FD dryers are single-phase units.

The refrigerant compressors (M1) of FD160 and FD210 dryers are equipped with a crankcase heater (Rs). When voltage is supplied, the heater is energized. It keeps the oil in the crankcase warm to prevent condensing of refrigerant in the compressor housing, which could result in serious damage of the compressor at start (liquid knock).

Fan control switch (S3) starts fan motor (M2) as soon as the condenser pressure reaches the upper set point of the switch and will stop the fan motor when the condenser pressure decreases to its lower set point.

High pressure shut-down switch (S2) stops the compressor motor when the pressure in the refrigerant circuit reaches the upper set point of the switch. The compressor motor will automatically restart when the pressure drops to the lower set point.

Both the fan motor and compressor motor have a built-in thermic protection. If the compressor motor stops without apparent reason, it will probably be the thermic protection which has tripped. In such case, the compressor will restart when the motor windings have cooled down, which may take up to 2 hours.

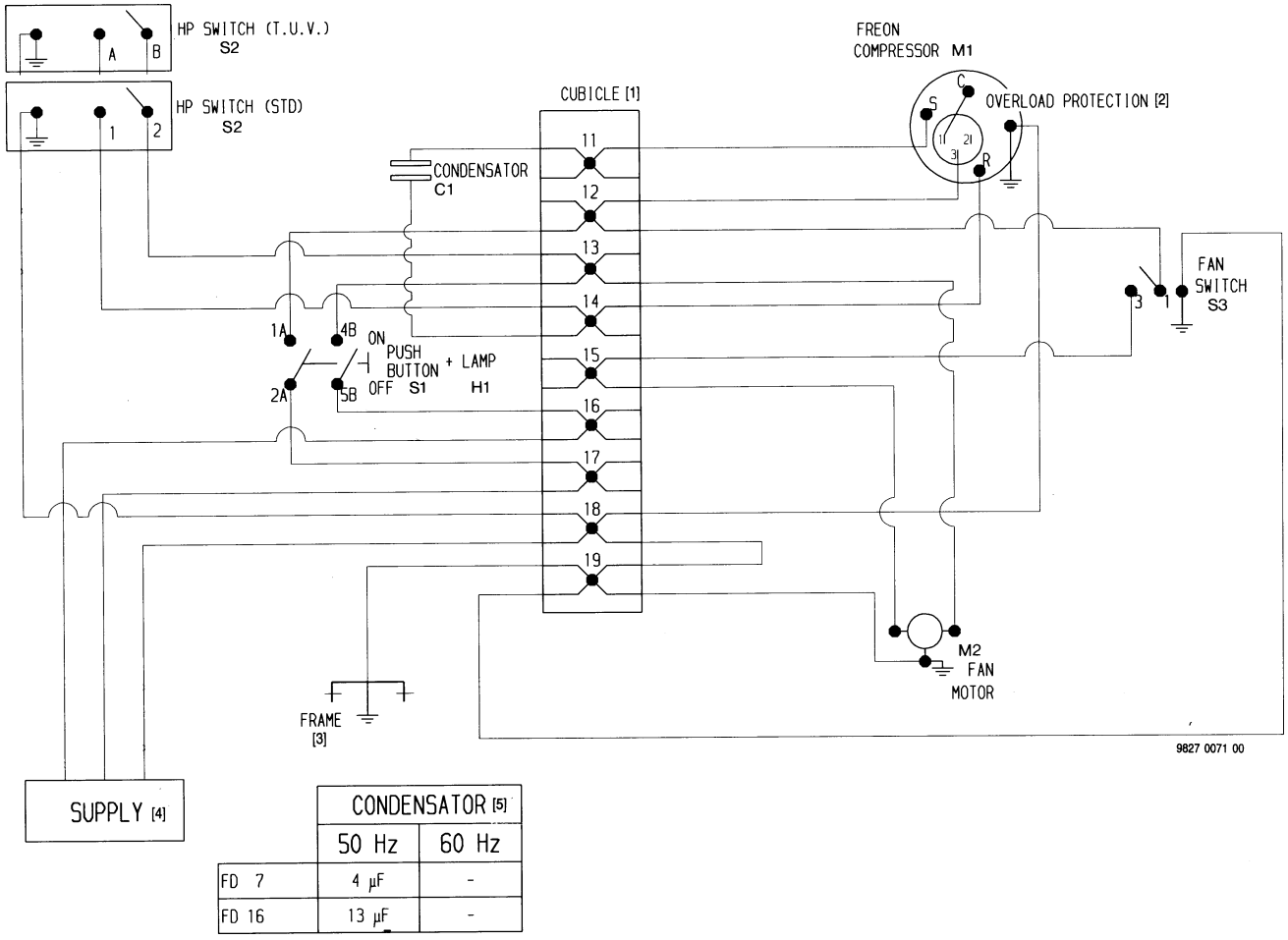
On FD160 60 Hz and FD210 60 Hz dryers, an electronic thermostat (Fig. 11b) with display and alarm functions is installed on the instrument panel. Display (8) shows the pressure dewpoint. The set point value, i.e. the pressure dewpoint at which the alarm indicator lamp (H3-Fig. 11a) lights up, can be checked by pressing key (10); the value will blink for approx. 5 seconds on the display. The differential value, i.e. the temperature difference between alarm on and alarm off, can be checked by pressing key (9); the value will blink on the display for approx. 5 seconds.

Altering the set point value (indicated "L1")
- Press key (10); the current value blinks on the display.
- Press the up (6) or down (7) key until the desired value is reached.
- To store the new value, press key (10) or wait a few seconds.

Altering the differential value (indicated "HY1")
- Press key (9); the current value blinks on the display.
- Press the up (6) or down (7) key until the desired value is reached.
- Press key (10) or wait a few seconds to store the new value.

C1. Condensator
F0. Main fuses, local installation (customer's installation)
F1-7. Fuses
F8. Thermal overload, fan motor
H1. Indicator lamp, VOLTAGE ON
H2. Indicator lamp, DRYER RUN
H3. Indicator lamp, DEWPOINT ALARM
K1. Motor contactor, refrigerant compressor
K2. Motor contactor, condenser cooling fan
K3. Timer (optional)
M1. Compressor motor
M2. Fan motor
Rs. Crankcase heater
R1. Temperature sensor, dewpoint
S0. Main switch, local installation (customer's installation)
S1. Button, ON-OFF
S2. High pressure shut-down switch
S3. Fan control switch
S4. Electronic thermostat with display
T1. Transformer
T2. Transformer
T3. Transformer
1X1/2. Terminal strips
Y1. Solenoid valve, interval drain (optional)

Figs. 4. Electrical diagrams



	CONDENSATOR [5]	
	50 Hz	60 Hz
FD 7	4 µF	-
FD 16	13 µF	-

Fig. 4a. FD7 and FD16 50 Hz/60 Hz

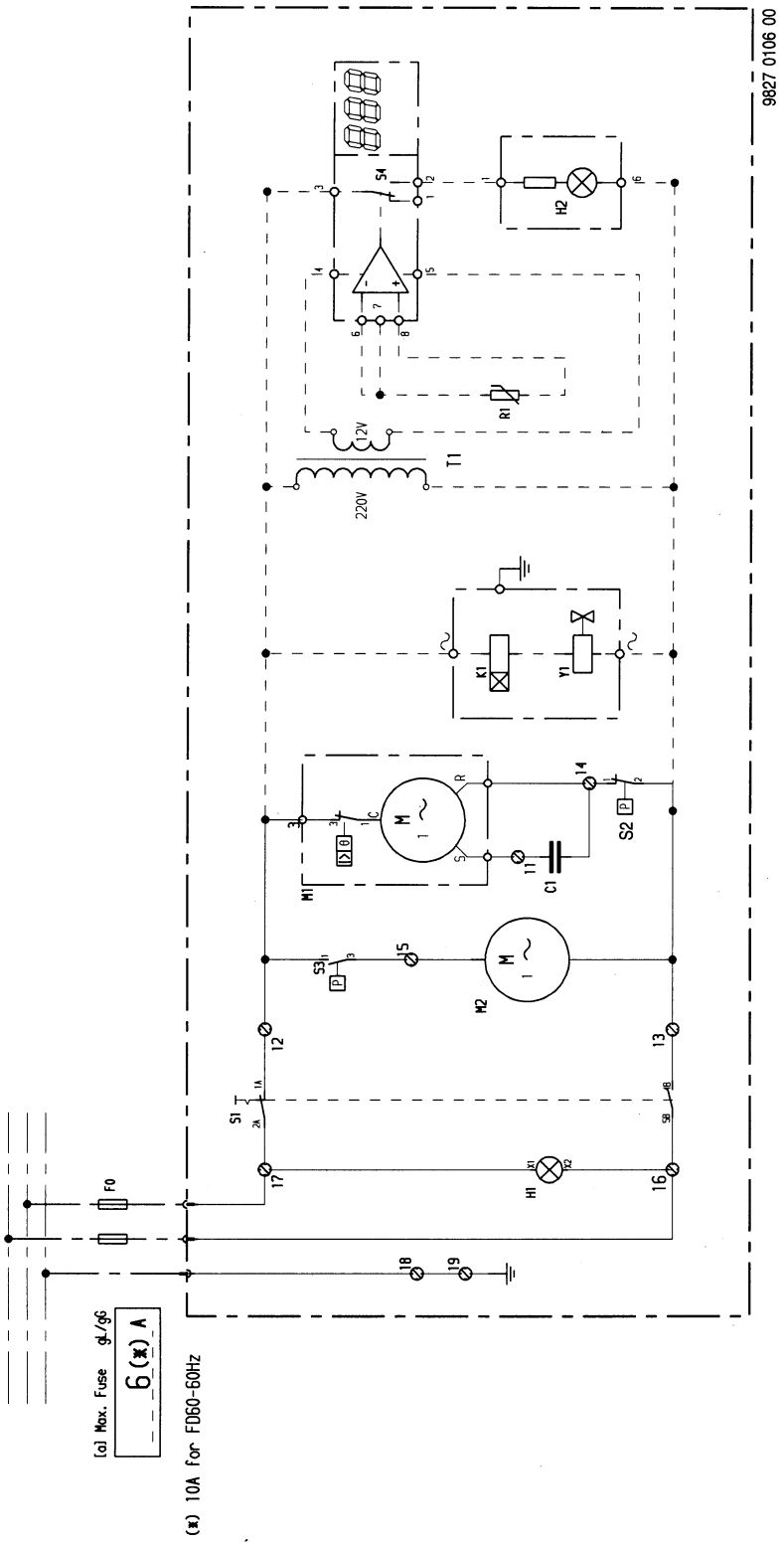


Fig. 4b. FD30, FD40 and FD60 50 Hz/60 Hz

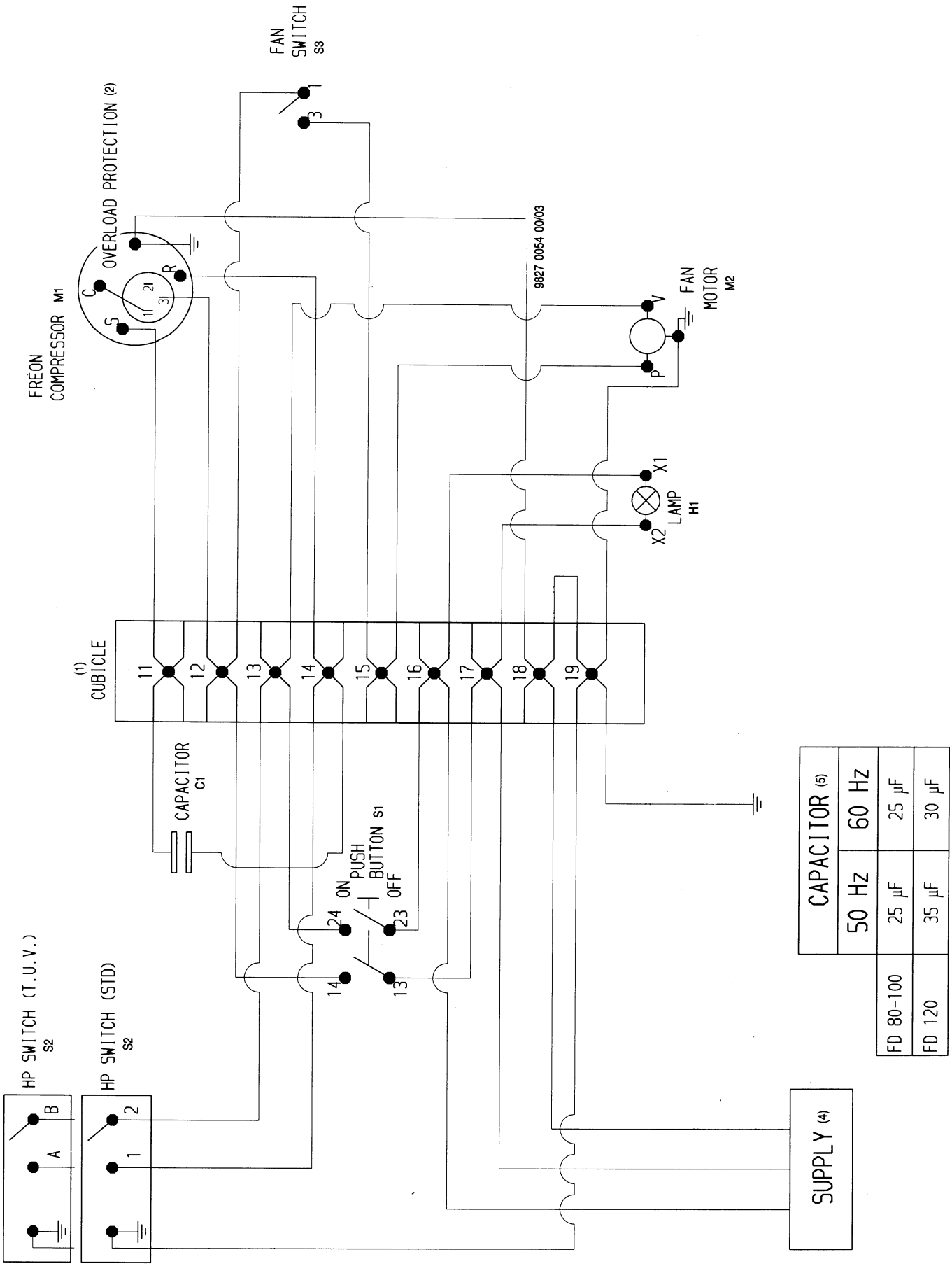


Fig. 4c. FD80, FD100 and FD120 50 Hz/60 Hz

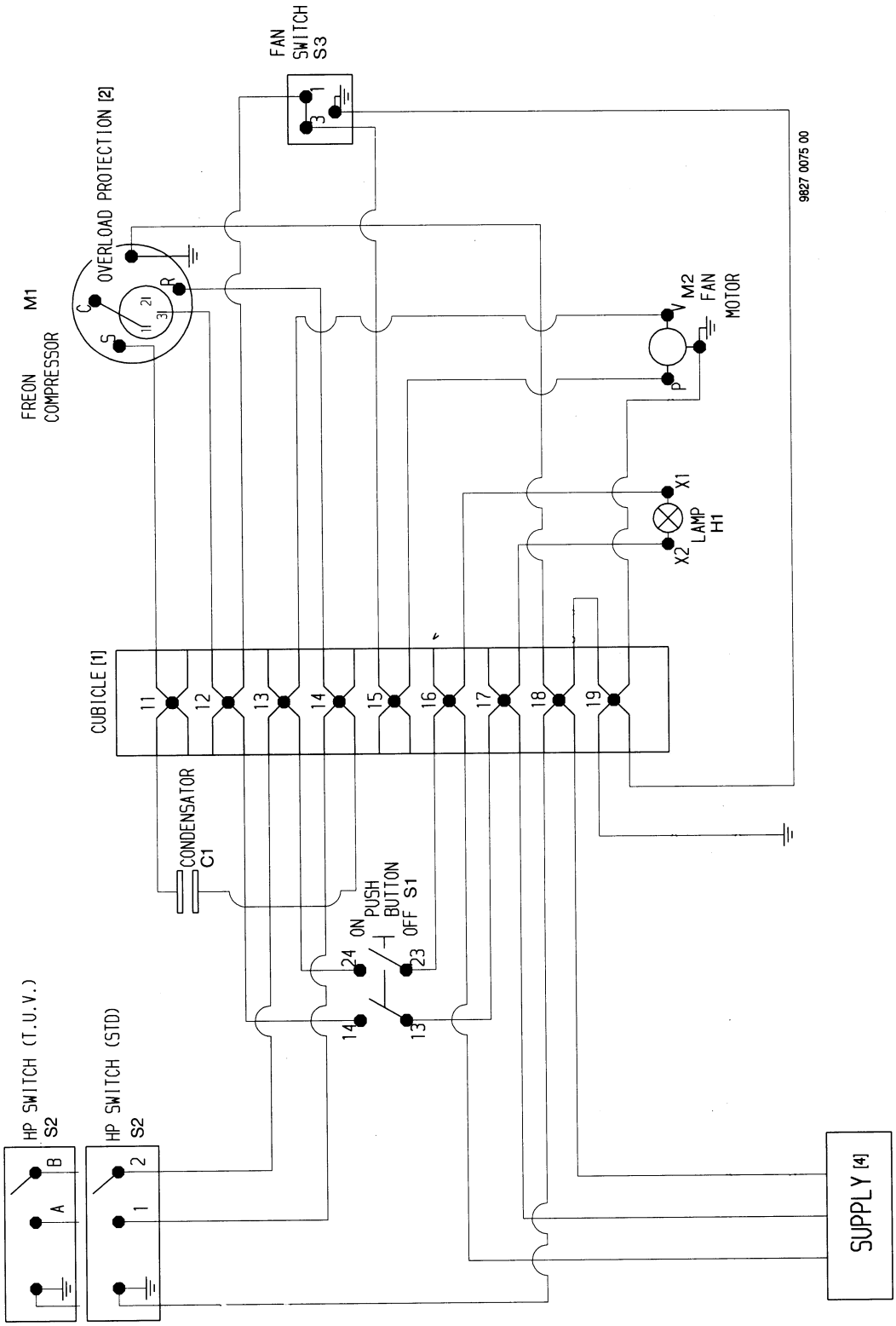


Fig. 4d. FD80, FD100 and FD120 60 Hz CSA/UL

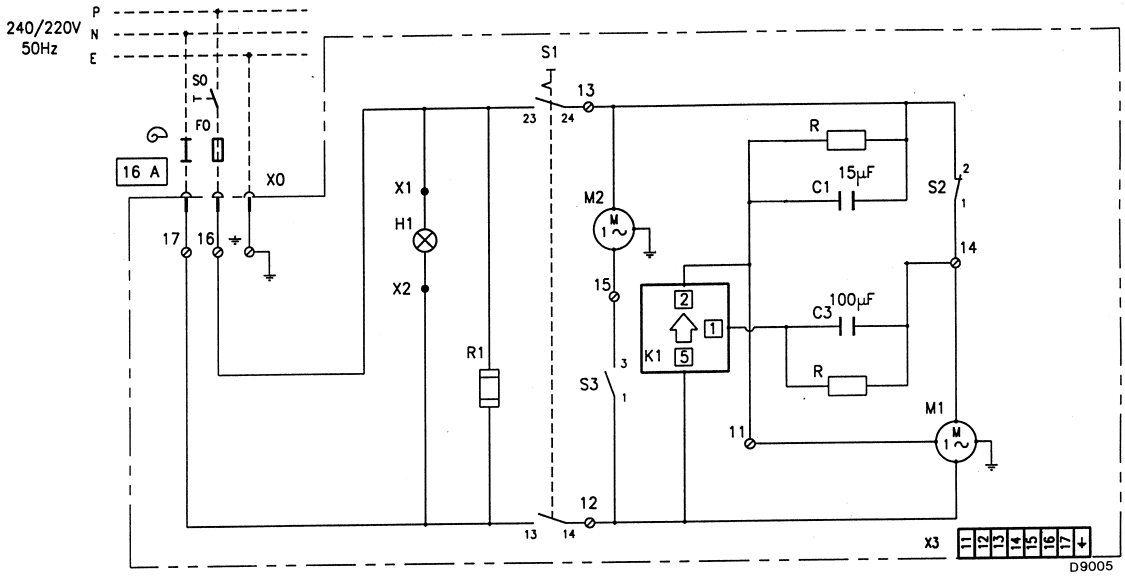


Fig. 4e. FD160-50 Hz and FD210-50 Hz

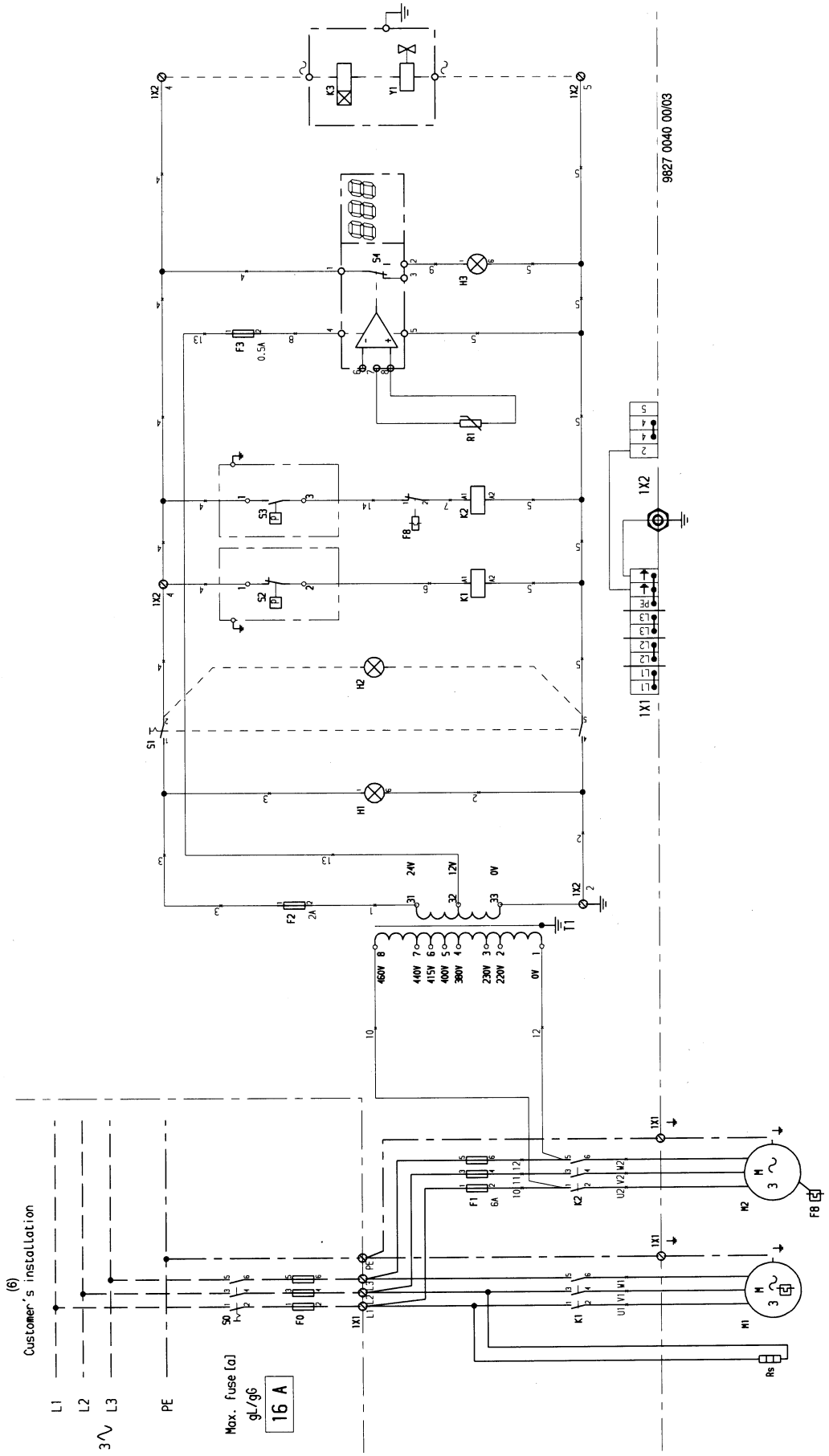


Fig. 4f. FD160-60 Hz and FD210-60 Hz IEC/VDE

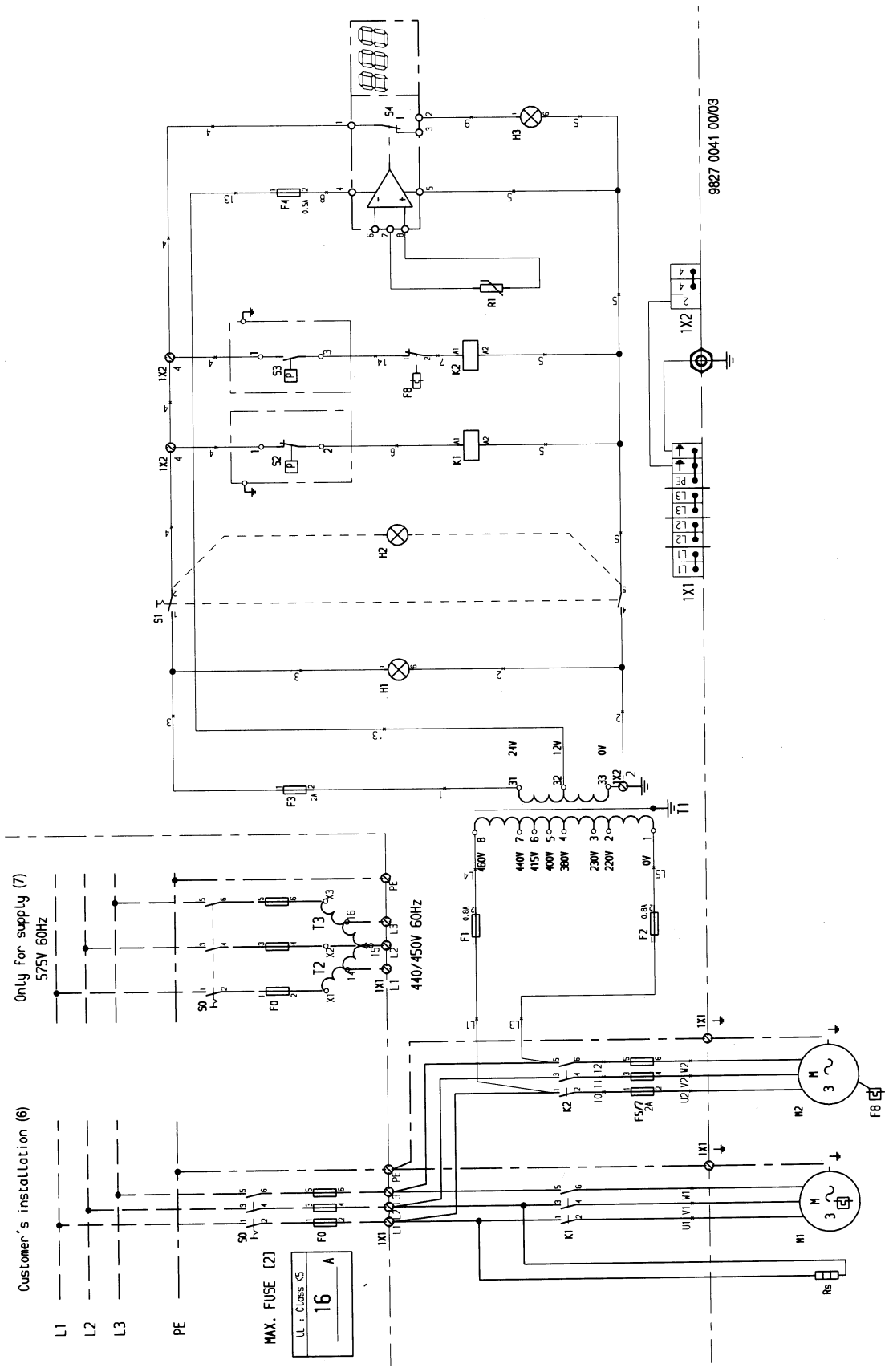


Fig. 4g. FD160-60 Hz and FD210-60 Hz CSA/UL

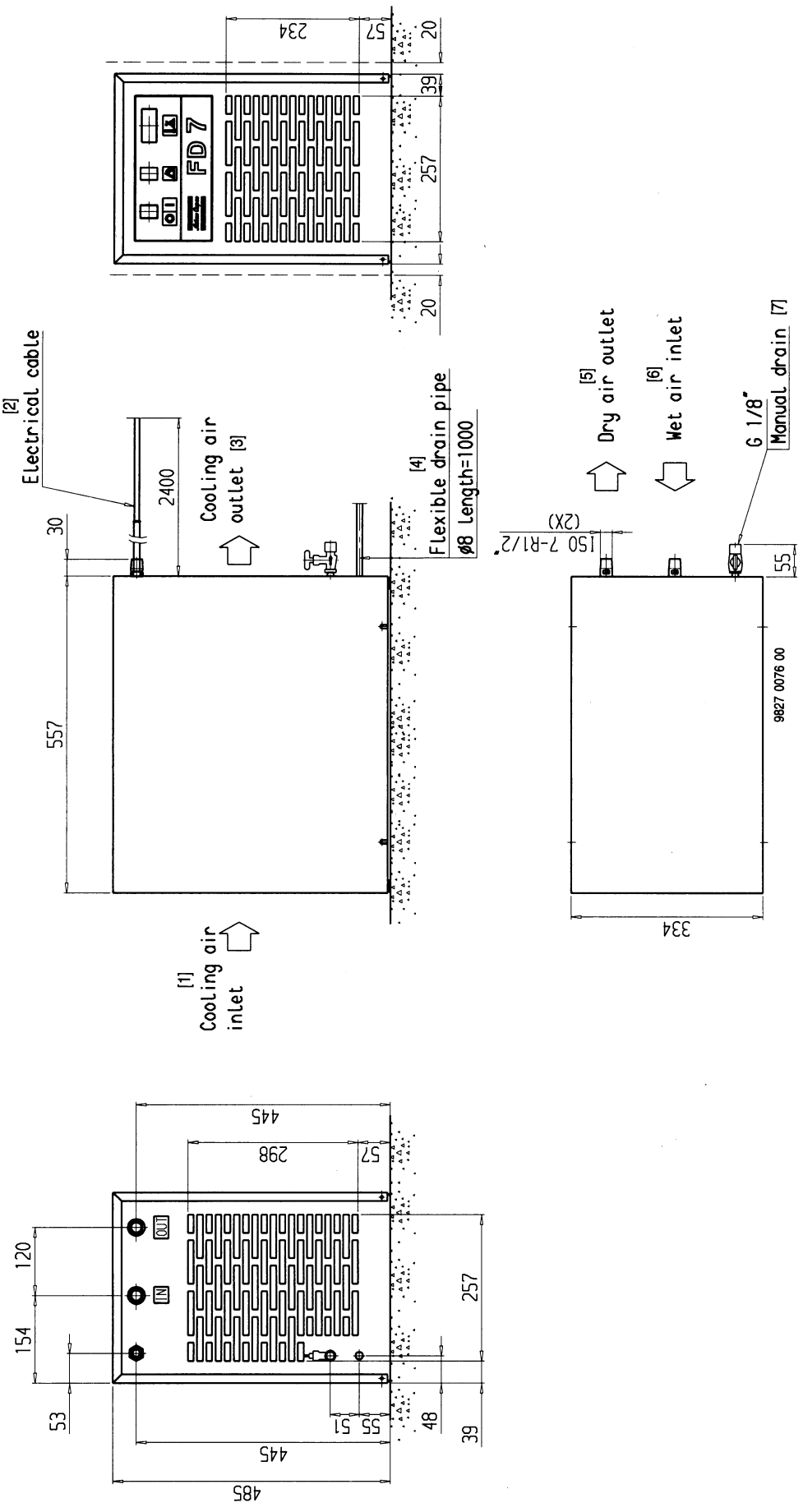


Fig. 5a. Dimension drawing of FD7/16

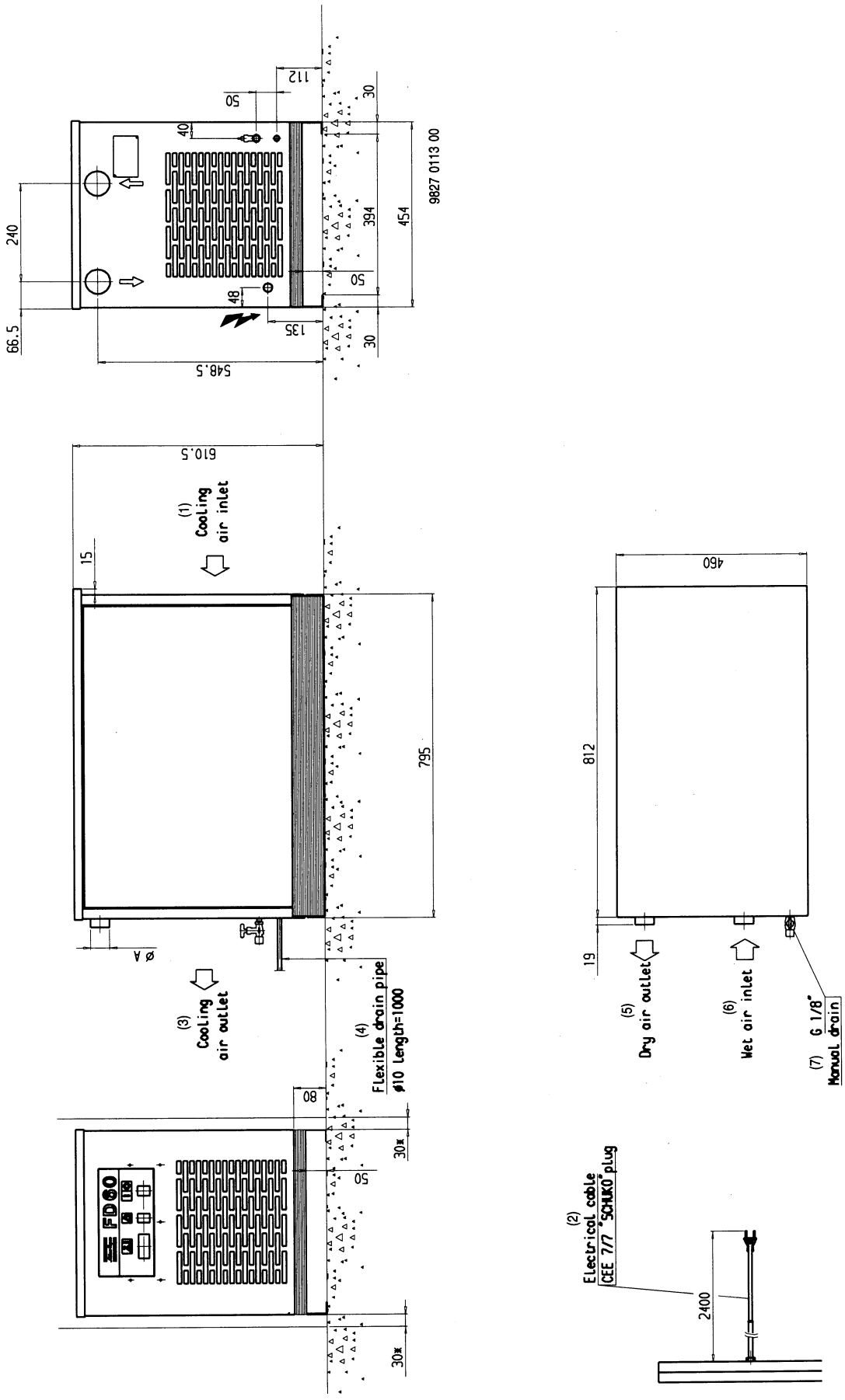


Fig. 5b. Dimension drawing of FD30, FD40 and FD60

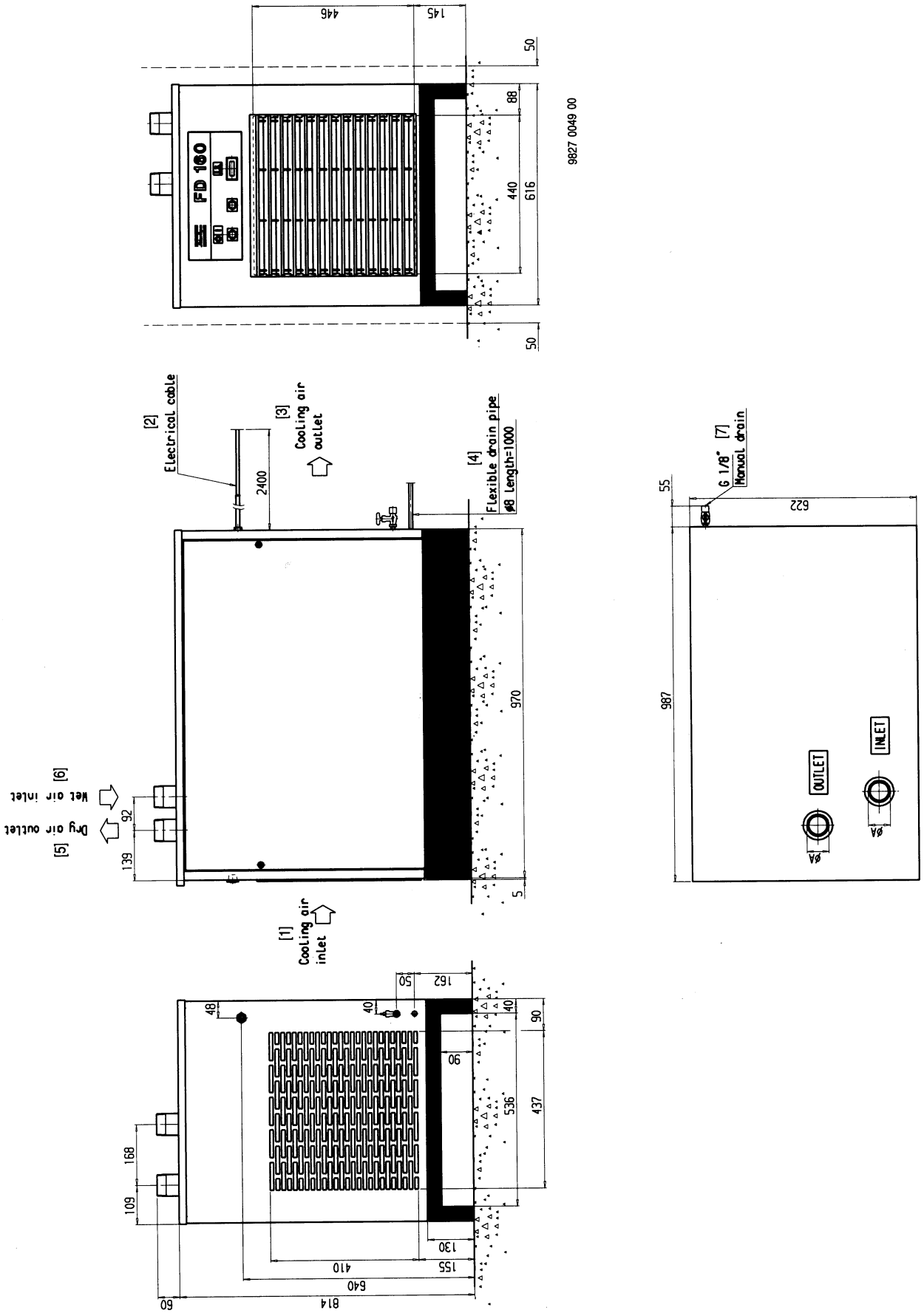


Fig. 5c. Dimension drawing of FD80, FD100, FD120 50/60 Hz and FD160 50 Hz

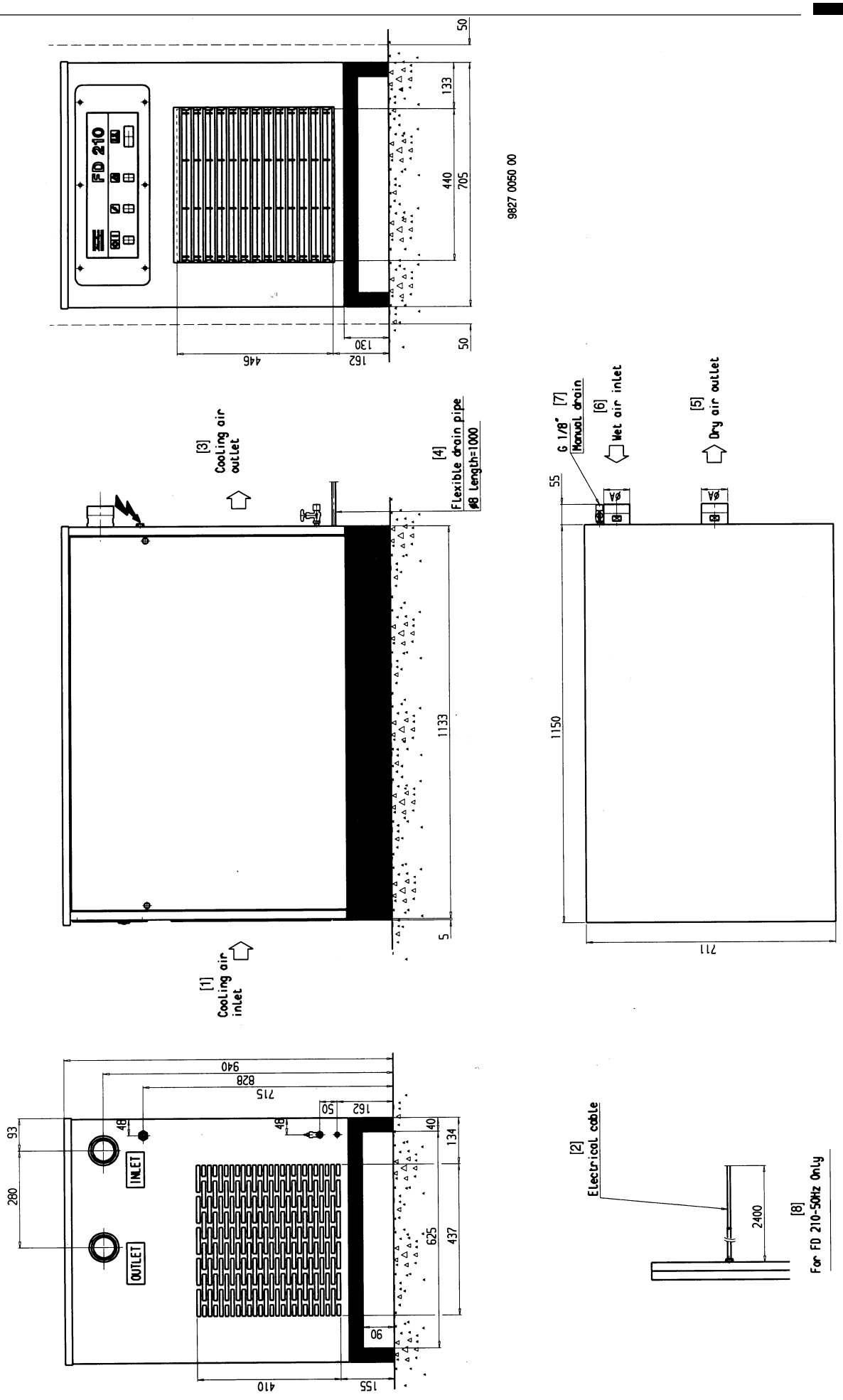


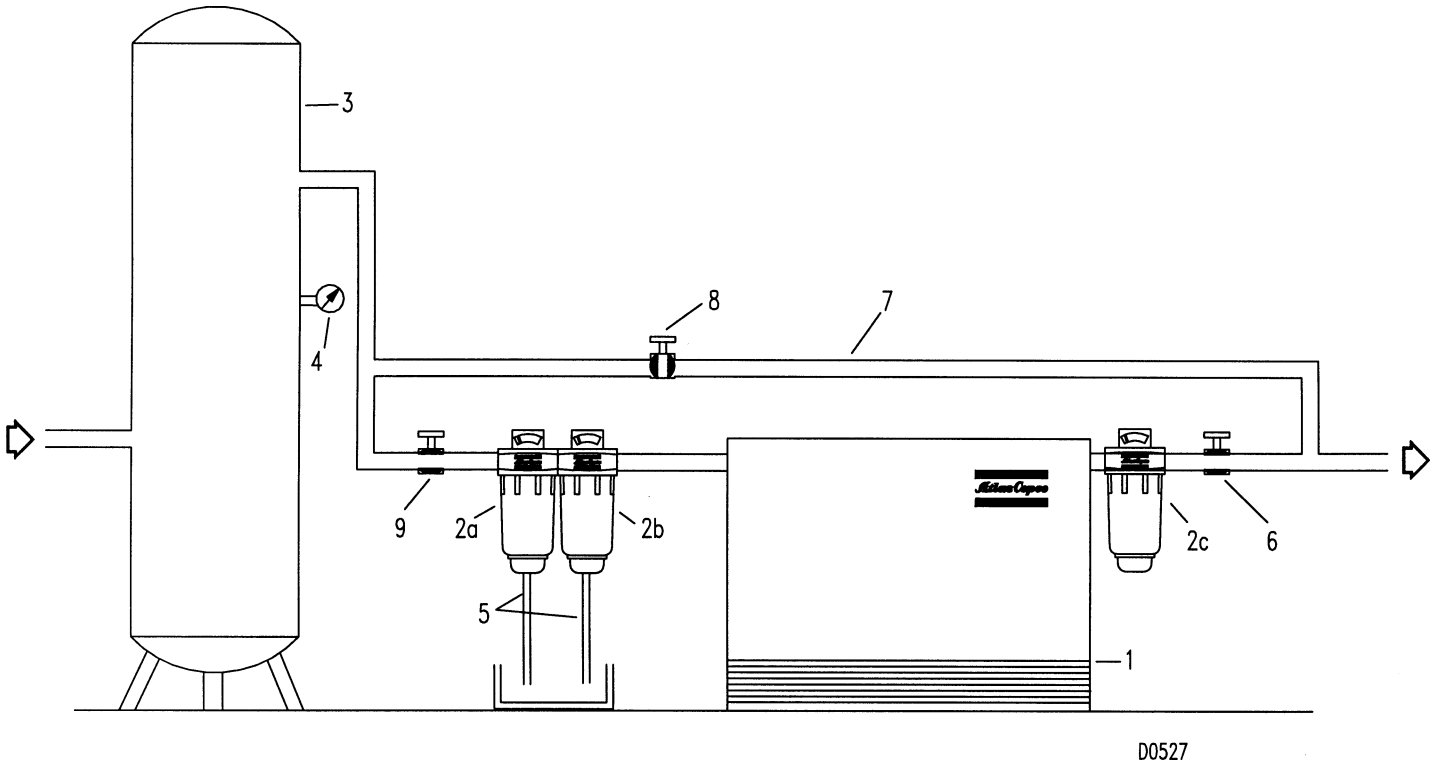
Fig. 5d. Dimension drawing of FD160 60 Hz and FD210 50/60 Hz

2 INSTALLATION

2.1 Dimension drawings (Figs. 5)

Type	Ø A	Net mass
FD7 50 Hz	ISO 7-R 1/2"	28 kg
FD16 50 Hz	ISO 7-R 1/2"	35 kg
FD30 50 Hz	ISO 7-R1"	72 kg
FD30 60 Hz	ISO 7-R1"	72 kg
FD40 50 Hz	ISO 7-R1"	72 kg
FD40 60 Hz	ISO 7-R1"	75 kg
FD60 50 Hz	ISO 7-R1"	75 kg
FD60 60 Hz	ISO 7-R1"	75 kg
FD80 50 Hz	ISO 7-R1 1/2"	130 kg
FD80 60 Hz	ISO 7-R1 1/2"	130 kg
FD100 50 Hz	ISO 7-R1 1/2"	130 kg
FD100 60 Hz	ISO 7-R1 1/2"	130 kg
FD120 50 Hz	ISO 7-R2"	135 kg
FD120 60 Hz	ISO 7-R2"	135 kg
FD160 50 Hz	ISO 7-R2"	157 kg
FD160 60 Hz	ISO 7-R2 1/2"	185 kg
FD210 50/60 Hz	ISO 7-R2 1/2"	190 kg

2.2 Installation proposal (Fig. 6)



1. FD dryer
2a. DD-type general-purpose prefilter
2b. PD-type high-efficiency prefilter
2c. DD-type afterfilter
3. Air receiver with condensate drain
4. Pressure gauge
5. Drain pipes
6. Dryer outlet valve
7. By-pass system
8. By-pass valve
9. Dryer inlet valve

Fig. 6. Installation proposal

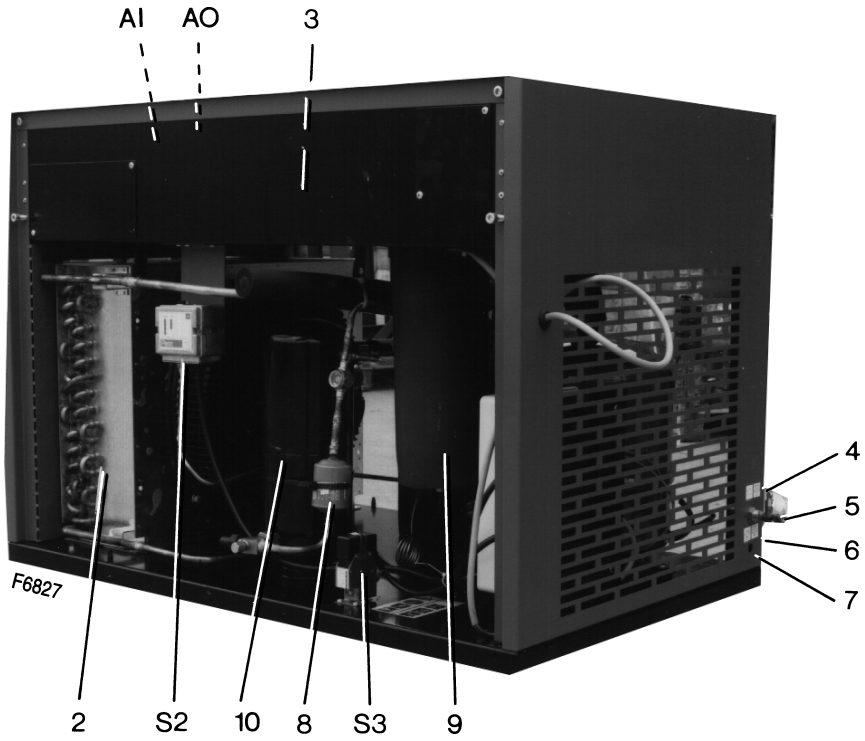


Fig. 7. FD160

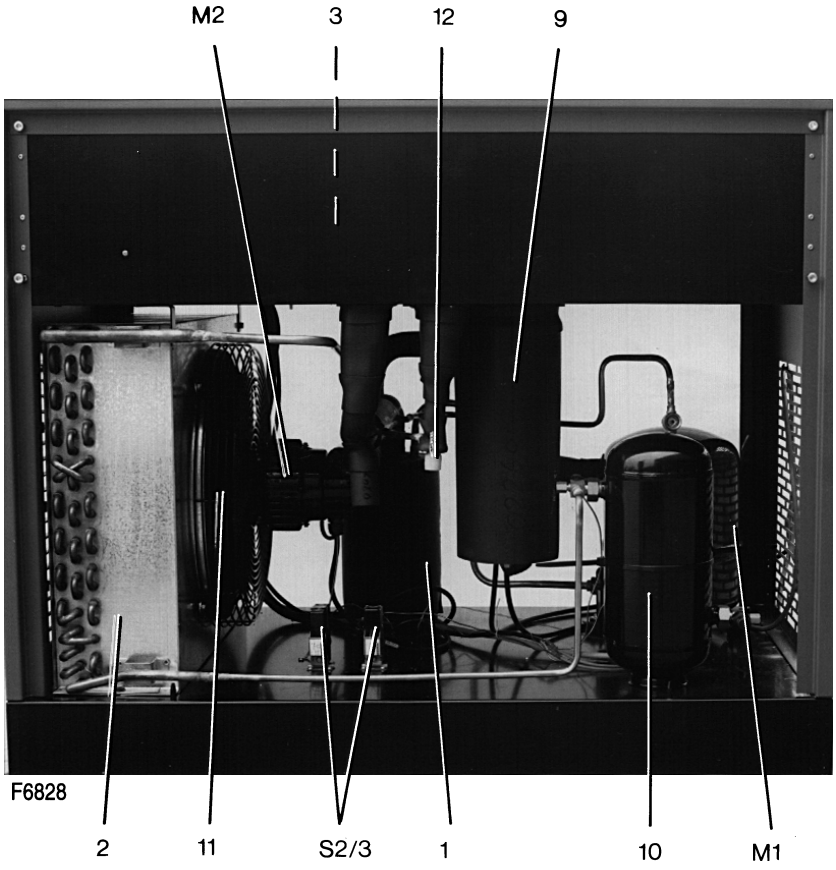


Fig. 8. FD210

AI. Air inlet
AO. Air outlet
M1. Refrigerant compressor
M2. Condenser fan motor
S2. High pressure shut-down switch
S3. Fan control switch
1. Liquid separator
2. Refrigerant condenser
3. Heat exchangers
4. Pictograph, manual condensate drain
5. Manual condensate drain valve
6. Pictograph, automatic condensate drain
7. Automatic condensate drain
8. Liquid refrigerant dryer
9. Condensate trap
10. Liquid refrigerant receiver
11. Condensor cooling fan
12. Refrigerant expansion valve

Figs. 7 and 8. Views of FD160 and FD210

2.3 Installation instructions

1. Install the dryer where the ambient air is as clean as possible and where the temperature of the air will never exceed the limits (see section 7). Keep the ventilation gratings of the dryer free.
2. Connect the compressed air lines to the marked inlet and outlet pipes of the dryer (Figs. 2 and 7). Provide an air inlet valve and outlet valve. If a by-pass pipe and valve are installed, the dryer can be serviced while by-passing the dryer.
3. Fit manual condensate drain valve (5-Fig. 7).
   Lay out the condensate drain hoses via a funnel towards a drain collector to allow visual inspection. The hoses must slope downwards. For draining of pure condensate, install an oil/water separator; consult Atlas Copco.
   If the condensate drain has been led down outside the compressor room where it may be exposed to freezing temperatures, it must be insulated.
4. A sticker dealing in short with the operating instructions and explaining the pictographs is delivered with the literature set. Affix the sticker next to the control panel. Make yourself familiar with the instructions and pictographs explained.
5. Remove all the bags with silica gel, if provided.

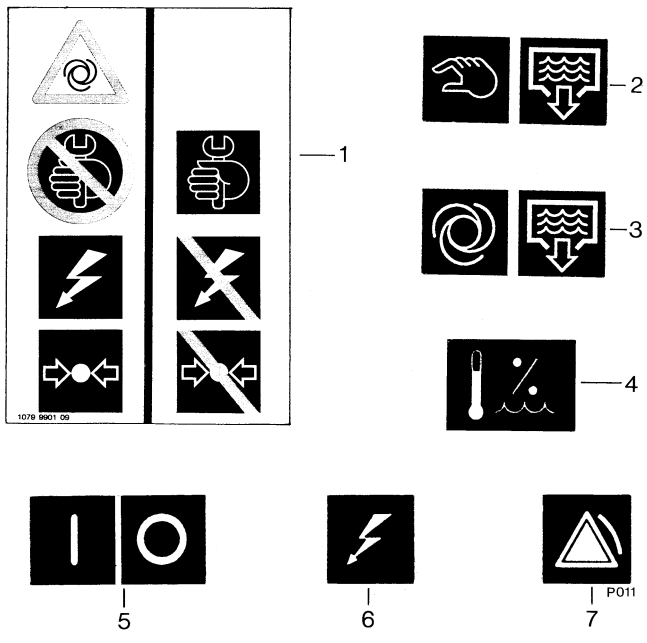
On 3-phase dryers (see section 1.5):

6. Check that the primary side connections of transformer (T1-Figs. 4f and 4g) correspond with the supply voltage.
7. Check that the electrical installation corresponds to the local codes. The dryer must be earthed and protected against short circuits by fuses of the inert type in all phases. An isolating switch must be installed near the dryer.

On single-phase dryers (see section 1.5):

8. Fit the electric plug to the voltage supply cable. Plug in the dryer.

2.4 Pictographs (Fig. 9)



1. Switch off and depressurize the dryer before starting maintenance or repairs
2. Manual condensate drain
3. Automatic condensate drain
4. Pressure dewpoint
5. Dryer on-off
6. Voltage on
7. Dewpoint alarm

Fig. 9. Pictographs

3 OPERATING INSTRUCTIONS

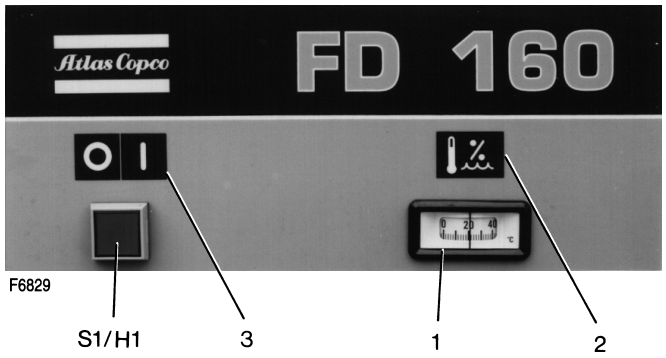
Safety precautions
The operator must apply all relevant safety precautions, including those mentioned in this book.

Altitude operation
Consult Atlas Copco if operating above 3000 m.

Moving/lifting
The dryer can be moved by a lift truck using the slot in the frame. Make sure that the forks protrude from the other side of the frame. The dryer can also be lifted after inserting beams in the slot. Make sure that the beams cannot slide and that they protrude from the frame equally. The chains must be held parallel to the bodywork by chain spreaders in order not to damage the dryer. The lifting equipment must be placed in such a way that the dryer will be lifted perpendicularly. Lift smoothly and avoid twisting.

3.1 Initial start (only for FD160 and FD210 dryers)

1. At least 4 hours before starting, the mains supply to the dryer must be switched on to energize the crankcase heater of the refrigerant compressor.
2. **On 3-phase dryers** (see section 1.5), press on-off button (S1-Fig. 11a). Check that the sense of rotation of fan motor (M2-Fig. 8) is correct. Cooling air must be drawn in through the condenser and blown over the refrigerant compressor to outside the dryer. If wrong, switch off the voltage and reverse two of the three phase connections at the mains terminals.



H1. Indicator lamp, VOLTAGE ON
S1. Button, ON-OFF
1. Pressure dewpoint indicator
2. Pictograph, pressure dewpoint
3. Pictograph, dryer on-off

Fig. 10. Control panel, FD160-50 Hz dryer (typical example)

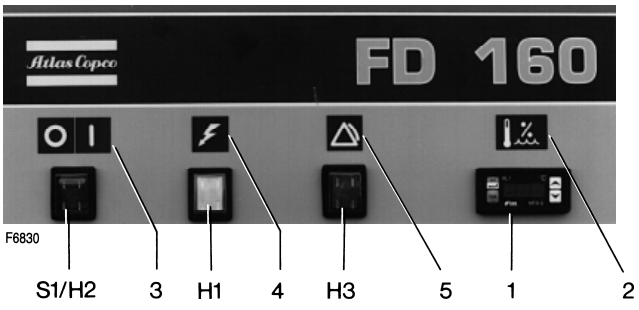


Fig. 11a. Control panel

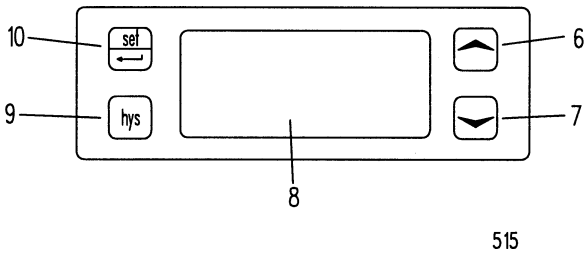


Fig. 11b. Detail of pressure dewpoint indicator

H1. Indicator lamp, VOLTAGE ON
H2. Indicator lamp, DRYER RUN
H3. Indicator lamp, pressure dewpoint ALARM
S1. Button, ON-OFF
1. Electronic thermostat with pressure dewpoint display
2. Pictograph, pressure dewpoint
3. Pictograph, on-off
4. Pictograph, voltage on
5. Pictograph, dewpoint alarm
6. Key, value up
7. Key, value down
8. Display
9. Key, differential value
10. Key, set point of maximum pressure dewpoint

Figs. 11. Control panel, FD160-60 Hz dryer (typical example)

3.2 Starting (Figs. 10 and 11)

1. On FD160 and FD210 dryers, switch on the voltage 4 hours before starting to energize the crankcase heater. Voltage on lamp (H1) is alight.
2. If installed, close the dryer by-pass valve.
3. Press on-off button (S1). On FD160 60 Hz and FD210 60 Hz, lamp (H2) lights up.
4. Open the dryer air inlet valve (customer's installation).
5. Approx. 5 minutes later, open the dryer air outlet valve (customer's installation).
6. Approx. 10 minutes later, the nominal dewpoint will be reached.

3.3 During operation

Regularly check:
1. Pressure dewpoint indicator (1-Figs. 10 and 11a). **1)**
2. That condensate is discharged (7-Fig. 7). The amount depends on the operating conditions.
3. Regularly open manual drain valve (5-Fig. 7) for approx. 10 seconds to discharge condensate and possible impurities.

3.4 Stopping (Figs. 10 and 11)

1. Close the dryer inlet and outlet valves (customer's installation).
2. Press on-off button (S1). The dryer stops. Voltage on lamp (H1) remains alight. On FD160 and FD210, the crankcase heater remains switched on. Leave the voltage on if the dryer has to remain stand-by.

4 MAINTENANCE

Cooling dryers of FD type contain refrigerant HFC (for FD7 up to FD60) and HCFC (for FD80 up to FD210) which can cause environmental harm when leaking.

Safety precautions
When handling refrigerant R22 or R134a, all applicable safety precautions must be observed. The following points are stressed:
- Contact of refrigerant with the skin will cause freezing. Special gloves must be worn and in case of contact, the skin should be rinsed with water. On no account may clothing be removed.
- Fluid refrigerant will also cause freezing of the eyes; therefore, **safety glasses** are a must.
- Refrigerant R22 and R134a are poisonous. Do not inhale refrigerant vapours. Check that the working area is adequately ventilated.

Local legislation may impose that:
- work in the refrigerant circuit of the cooling dryer or on any equipment which influences its function should according to the law be executed by an **authorized control body.**
- the installation should according to the law be checked once a year by an **authorized control body.**

General
- Keep the dryer clean.
- Brush or blow off the finned surface of condenser (3-Fig. 1) regularly.
- Once every six months inspect and clean the inner components of condensate trap (9-Figs. 7 and 8).

5 SETTINGS

The regulating and safety devices are factory-adjusted to obtain optimum performance of the dryer. Do not alter the setting of any of the devices.

5.1 Automatic expansion valve (12-Fig. 8)

The automatic expansion valve is a regulator which keeps the evaporator pressure, and consequently also the temperature, stable. The valve is factory-set to keep the evaporator pressure at no-load at a minimum of 2.05 bar(e) (29.7 psig) for FD7 up to FD60 and 4.1 bar(e) (59 psig) for FD80 up to FD210, which corresponds to 1 C (34 F).

5.2 Switches (Figs. 7 and 8)

Fan control switch (S3) and high pressure shut-down switch (S2) are factory-adjusted and must be replaced if they deviate.

Switches	Dryer	Cut-out at:	Switch-on at:
Fan control switch (S3)	FD7, -16	8.1 bar(e)	10.6 bar(e)
	FD30, -40, -60	9 bar(e)	10 bar(e)
	FD80, -100, -120	13 bar(e)	16 bar(e)
	FD160	13 bar(e)	16 bar(e)
	FD210	12 bar(e)	14 bar(e)
High pressure shut-down switch (S2)	FD7 up to FD60	17 bar(e)	14 bar(e)
	FD80 up to FD210	25 bar(e)	20 bar(e)

1) The pressure dewpoint will deviate from nominal if the air inlet conditions or volume flow differ from nominal.

6 PROBLEM SOLVING (Fig. 3)

1. Pressure dewpoint too high
- a. Air inlet temperature too high
- a. Check and correct; if necessary, install a pre-cooler
- b. Ambient temperature too high
- b. Check and correct; if necessary, draw cooling air via a duct from a cooler place or relocate dryer
- c. Air inlet pressure too low
- c. Increase inlet pressure
- d. Dryer capacity exceeded
- d. Reduce air flow
- e. Shortage of refrigerant
- e. Have circuit checked for leaks and recharged
- f. Refrigerant compressor (M1) does not run
- f. See 3
- g. Evaporator pressure too high
- g. See 6
- h. Condenser pressure too high
- h. See 2

2. Condenser pressure too high or too low
- a. Fan control switch (S3) out of order
- a. Replace
- b. Fan or fan motor out of order
- b. Check fan/fan motor
- c. Ambient temperature too high
- c. Check and correct; if necessary, draw cooling air via a duct from a cooler place or relocate dryer
- d. Condenser externally clogged
- d. Clean condenser

3. Compressor stops or does not start
- a. Electric power supply to compressor is interrupted
- a. Check and correct as necessary
- b. Thermic protection of refrigerant compressor motor (M1) has tripped
- b. Motor will restart when motor windings have cooled down
- c. High pressure shut-down switch (S2) has tripped
- c. Switch resets automatically when pressure has decreased
- d. Thermic protection of fan motor (M2) has tripped
- d. Fan motor will restart when windings have cooled down

4. Condensate trap remains inoperative
- a. Automatic drain system clogged
- a. Flush the assembly by opening manual drain valve. Have system inspected

5. Condensate trap continuously discharges air and water
- a. Automatic drain system out of order
- a. Have system checked

6. Evaporator pressure is too high or too low
- a. Expansion valve incorrectly set or out of order
- a. Have expansion valve adjusted
- b. Condenser pressure too high or too low
- b. See 2
- c. Shortage of refrigerant
- c. Have circuit checked for leaks and recharged

7 PRINCIPAL DATA

7.1 Limitations/nominal conditions

		50 Hz	60 Hz
Nominal conditions			
Compressed air inlet pressure	bar(e)	7	7
Compressed air inlet temperature	C	35	38
Ambient temperature	C	25	38
Inlet relative vapour pressure		1	1
Pressure dewpoint	C	3	4
Cooling air inlet temperature	C	25	38
Limitations			
Maximum compressed air inlet pressure	bar(e)	10.5	10.5
Min-max ambient air temperature	C	0-45	0-50
Min-max compressed air inlet temperature	C	0-55	0-60

7.2 Specific data of FD7 and FD16 1)

			FD7	FD16
Volume flow at dryer inlet at nominal conditions	50 Hz	l/s	7	16
	60 Hz	l/s		19
Pressure drop through dryer at nominal conditions, approx.	50 Hz	bar	0.10	0.17
	60 Hz	bar		0.21
Electric power input	50 Hz	kW	0.20	0.40
	60 Hz	kW		0.50
Refrigerant				
Tetrafluoroethane CH_2FCF_3			R134a	R134a
Total charge, approx.		kg	0.9	0.9

1) At reference conditions

7.3 Specific data of FD30, FD40 and FD60 1)

			FD30	FD40	FD60
Volume flow at dryer inlet at nominal conditions	50 Hz	l/s	30	40	60
	60 Hz	l/s	34	50	62
Pressure drop through dryer at nominal conditions, approx.	50 Hz	bar	0.13	0.19	0.19
	60 Hz	bar	0.13	0.11	0.20
Electric power input	50 Hz	kW	0.47	0.57	0.67
	60 Hz	kW	0.8	0.92	1.35
Refrigerant					
Tetrafluoroethane CH_2FCF_3			R134a	R134a	R134a
Total charge, approx.	50 Hz	kg	1.30	1.65	2.50
	60 Hz	kg	1.65	2.50	2.50

7.4 Specific data of FD80, FD100 and FD120 1)

			FD80	FD100	FD120
Volume flow at dryer inlet at nominal conditions	50 Hz	l/s	80	100	120
	60 Hz	l/s	90	108	132
Pressure drop through dryer at nominal conditions, approx.	50 Hz	bar	0.10	0.13	0.13
	60 Hz	bar	0.10	0.11	0.16
Electric power input	50 Hz	kW	1.00	1.00	1.30
	60 Hz	kW	1.42	1.83	1.88
Refrigerant					
Difluormonochlormethane CHF2Cl			R22	R22	R22
Total charge, approx.		kg	2.8	2.8	2.8

7.5 Specific data of FD160 and FD210 1)

			FD160	FD210
Volume flow at dryer inlet at nominal conditions	50 Hz	l/s	160	210
	60 Hz	l/s	170	225
Pressure drop through dryer at nominal conditions, approx.	50 Hz	bar	0.13	0.11
	60 Hz	bar	0.10	0.14
Electric power input	50 Hz	kW	1.60	1.70
	60 Hz	kW	2.00	3.20
Refrigerant				
Difluormonochlormethane CHF2Cl			R22	R22
Total charge, approx.	50 Hz	kg	4.1	4.8
	60 Hz	kg	4.8	4.8

8 CONVERSION LIST OF SI UNITS INTO BRITISH UNITS

1 bar = 14.504 psi
1 g = 0.035 oz
1 kg = 2.205 lb
1 km/h = 0.621 mile/h
1 kW = 1.341 hp (UK and US)
1 l = 0.264 US gal
1 l = 0.220 Imp gal (UK)
1 l = 0.035 cu.ft
1 m = 3.281 ft
1 mm = 0.039 in
1 m^3/min = 35.315 cfm
1 mbar = 0.401 in wc
1 N = 0.225 lbf
1 Nm = 0.738 lbf.ft
x C = (32 + 1.8x) F **2)**

1) At reference conditions
2) A temperature difference of 1 C = a temperature difference of 1.8 F