Chapter 4 Troubleshooting

1. Troubleshooting 4-2

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This chapter describes how to deal with troubles that may occur while the automotive IGBT module is handled.

1. Troubleshooting

When the IGBT module is installed in an inverter circuit, etc. a failure of the IGBT module might be occurred due to improper wiring or mounting. Once a failure is occurred, it is important to identify the root cause of the failure. Table 4-1 illustrates how to determine a failure mode as well as the original causes of the failure by observing irregularities outside of the device. First of all, estimate a failure mode of the module by using the table when a failure is happened. If the root cause cannot be identified by using Table 4-1, see Fig. 4-1 as detailed analysis chart for helping your further investigation.

Table 4-1(a) Estimated causes and its device failure modes

External abnormalities		Cause		Device failure mode	Further checkpoints
Short circuit	Arm short-circuit	After short-circuit detection, surge voltage excess SCSO		Outside SCSOA	Integrity waveform of locus and device ruggedness
	Series arm short-circuit	Insufficient dead time	Large t_{off} due to reverse gate bias dead time setting mistakes	Over heating	Integrity device t_{off} and dead time
		d*v*/d*t* malfunction	less reverse gate bias too long gate wiring	SCSOA and/or overheat	Faulty turn-on due to d*v*/d*t*
		Noise induced	Gate circuit malfunction Logic circuit malfunction		Confirm circuit malfunction
	Output short-circuit	Faulty wiring, abnormal wire contact, load short-circuit			Confirm failure phenomenon Integrity between device ruggedness and protection function Wiring conditions
	Ground short	Faulty wiring, abnormal wire contact			
Overload		Overcurrent	Logic circuit malfunction	Overheating	Logic signal
			protection function setting fault		Redesign of protection condition
Overvoltage	Excessive DC voltage	Overvoltage larger than device breakdown voltage apply between Corrector and Emitter	Excessive input voltage	Excess ratings of V_{CE}	Redesign of protection condition
			Overvoltage protection		
	Excessive spike voltage	Destruction due to excessive surge voltage larger than RBSOA at turn-off		RBSOA	Integrity confirmation RBSOA and operating locus at turn-off Redesign of snubber circuit
		Destruction due to excessive surge voltage larger than device breakdown voltage at reverse recovery		Overvoltage of V_{CES}	Integrity spike voltage and device breakdown voltage snubber circuit
		Reverse recovery phenomenon at operating with very narrow gate pulse *1)	logic circuit or gate circuit malfunction due to noise		Logic circuit and/or gate circuit
			Electromagnetic induction noise from main circuit to gate wiring		Mutual interference between gate circuit and main circuit
		Destruction by the main circuit wiring is too long, the surge voltage at the time of the turn-off to reach the dynamic avalanche voltage		Destruction due to dynamic avalanche	Redesign of main circuit inductance

*1) Excessive reverse recovery voltage over device breakdown voltage is produced, if gate pulse width is less than few hundrednano second.

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Table 4-1(b) causes of device failure modes

External abnormalities		Cause		Device failure mode	Further checkpoints
driver supply voltage drop		V_{CE} is increased by V_{GE} lower than specified value. As a result, power consumption and Joule head are increased.	DC/DC converter malfunction	Overheat	Each circuit design
			Too much time constant of power supply settling		
			Gate wiring break		
Excessive gate voltage		Electro static discharge on V_{GE}		Excessive V_{GES}	Assembly area environment against ESD
		Spike voltage larger than V_{GES} is produced by too long gate wiring			Gate voltage
Operation under opened gate circuit		Voltage apply to Corrector and Emitter while gate is opened.		Overheat	Gate voltage
Overvoltage on temperature diode, sense IGBT		Temperature diode and/or sense IGBT destruction due to ESD		ESD	Assembly area environment against ESD
Overheat	Lack of heat dissipation capacity	Anomalous heating due to lack of heat dissipation capacity	Less flow rate	Overheat	Radiation condition or radiation design
			Radiator malfunction		
	Thermal runaway	Total dissipation is increased by carrier frequency increased due to logic circuit malfunction.			Logic circuit on gate
Stress	Stress	Soldered portion is broken by stress fatigue	Stress from external wiring	Disconnection of circuit	Mechanical stress due to mounting condition
	Vibration		Stress induced vibration		
Reliability (Life time)		The application condition exceeds the reliability of the module.		Destruction is different in each case.	Refer to Fig. 4-1 (a-f)

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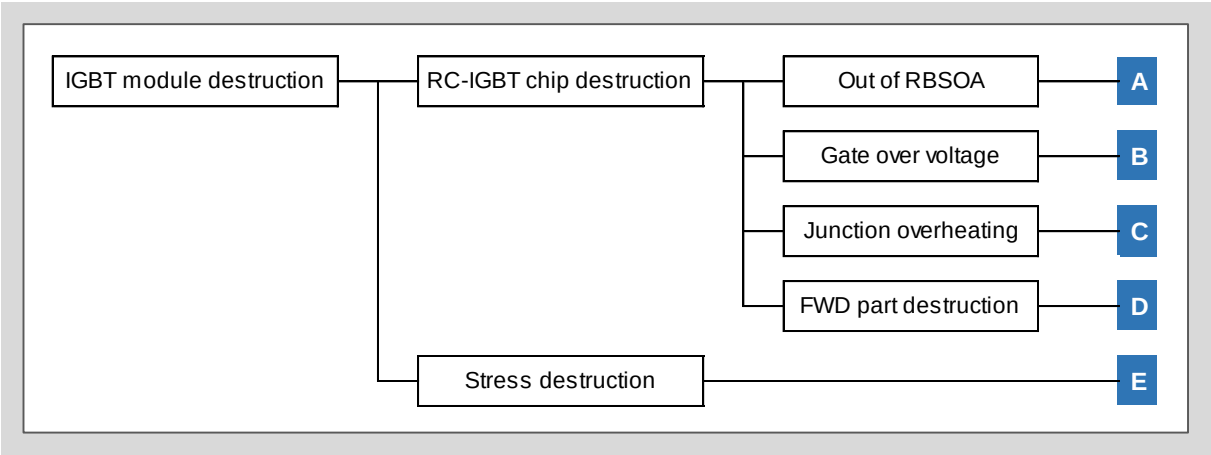

Fig. 4-1(a) IGBT module failure analysis

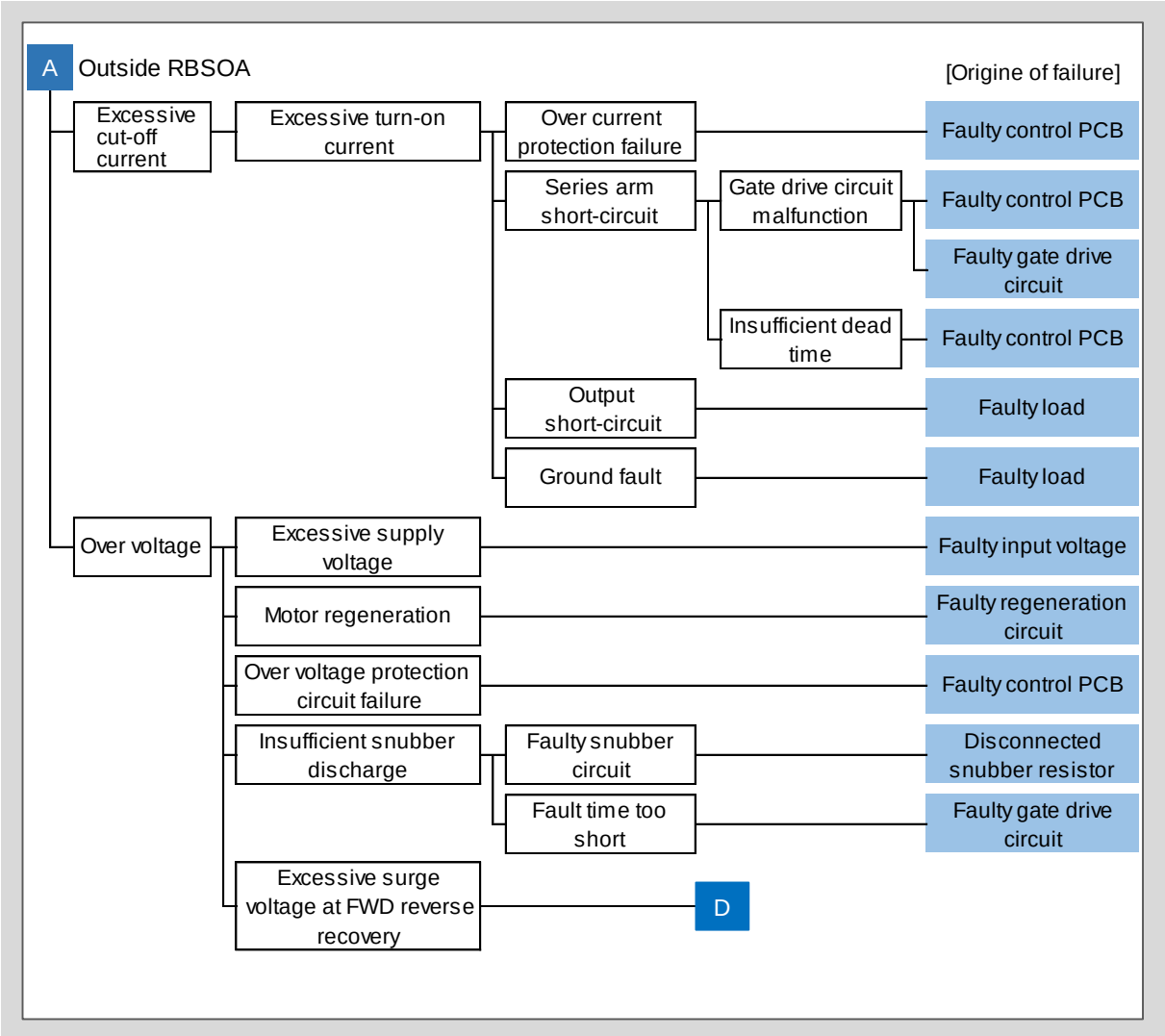

Fig. 4-1(b) Mode A: Outside RBSOA

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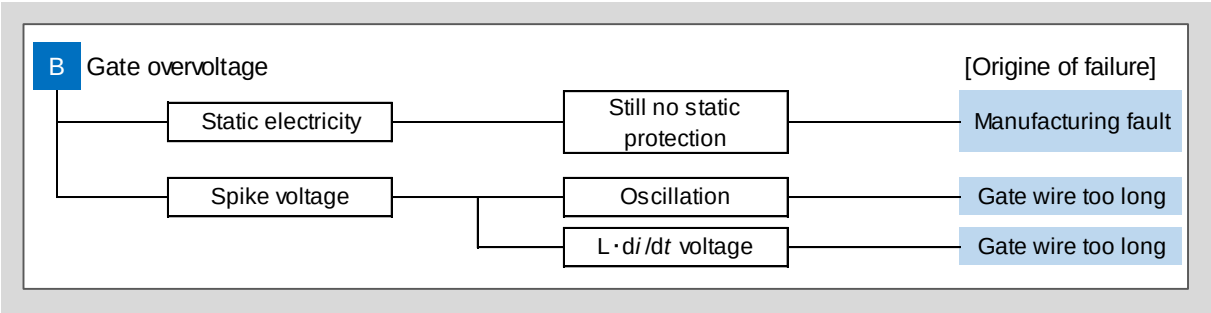

Fig. 4-1(c) Mode B: Gate overvoltage

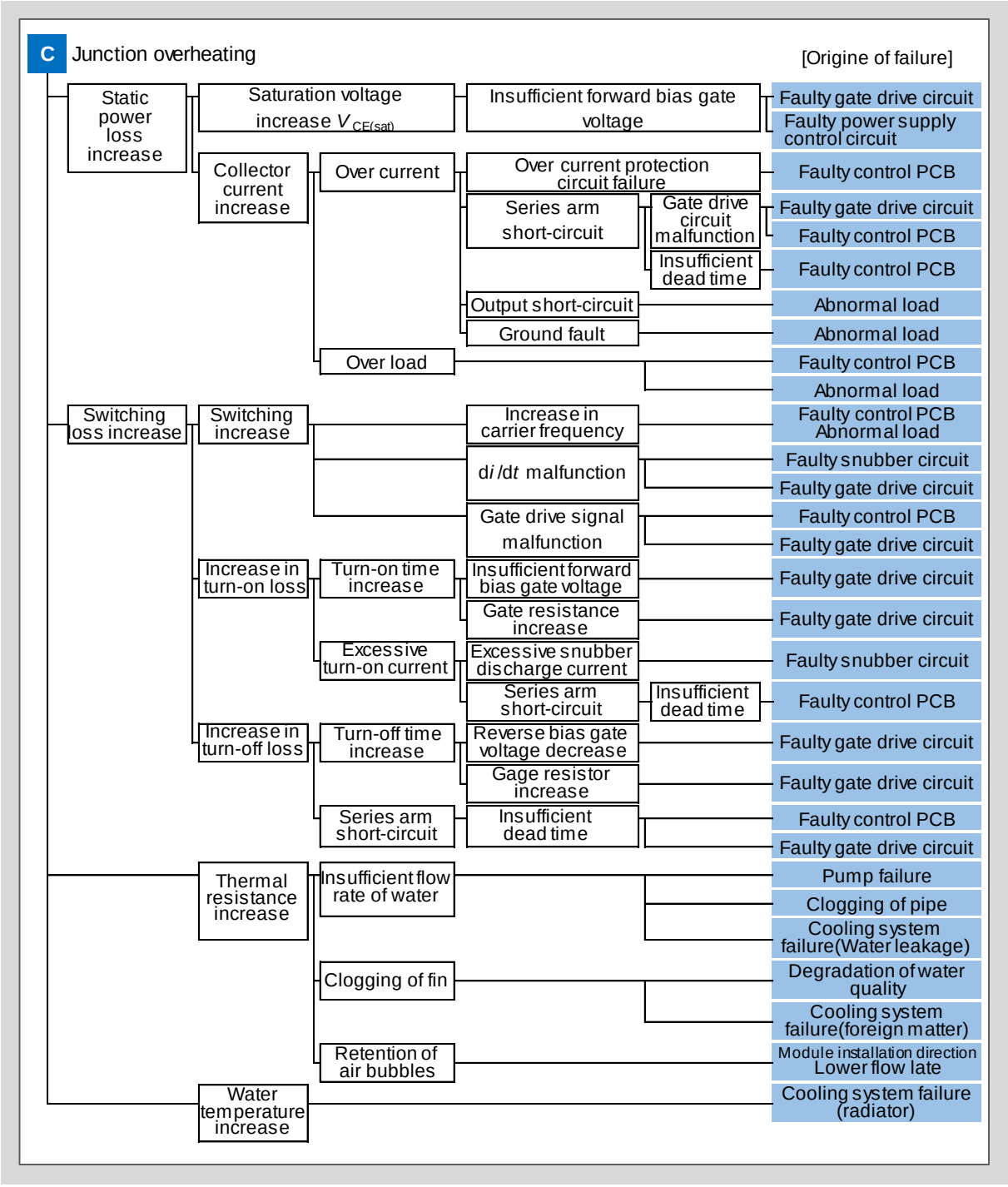

Fig. 4-1(d) Mode C: Junction over heating

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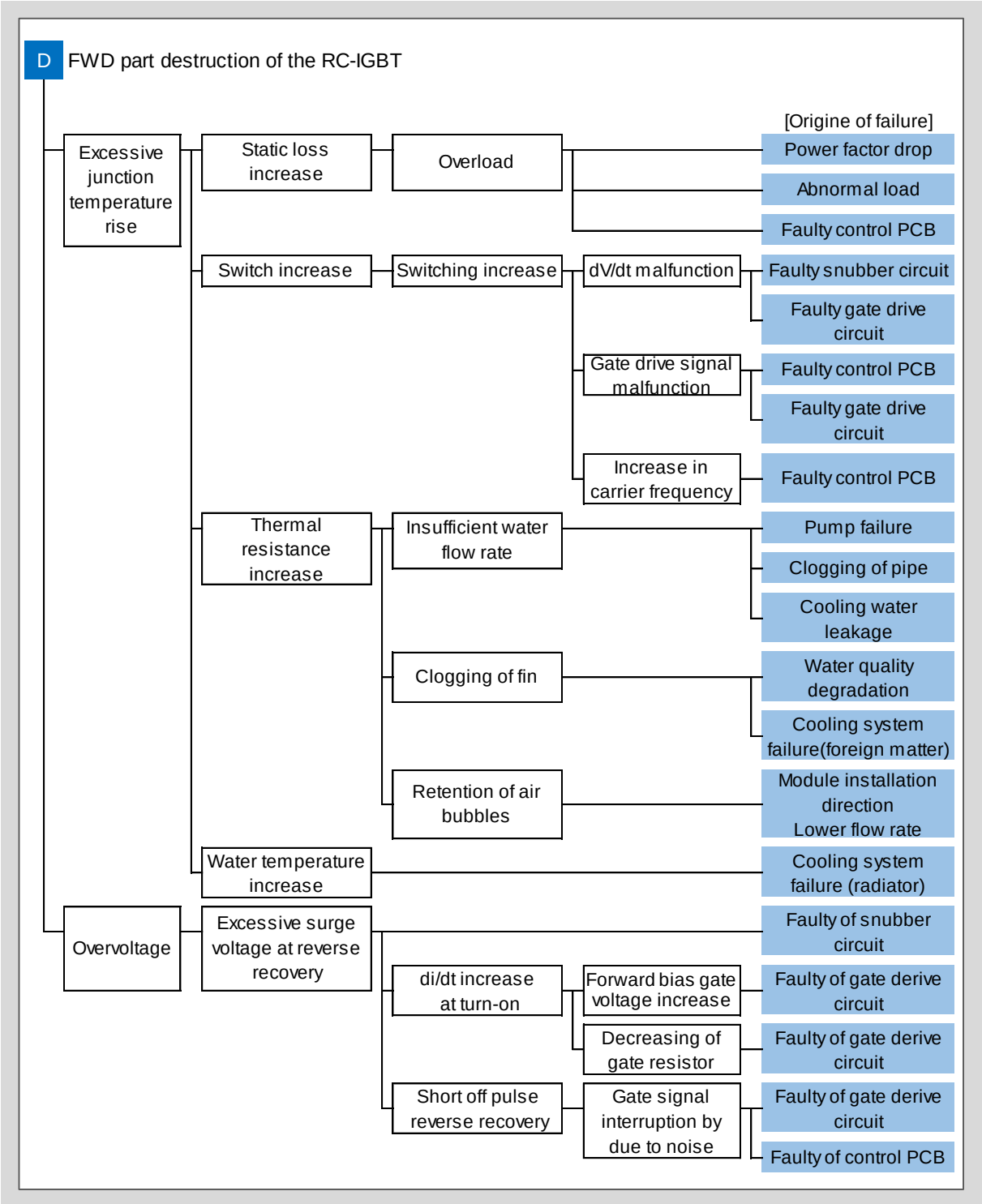

Fig. 4-1(e) Mode D: FWD destruction

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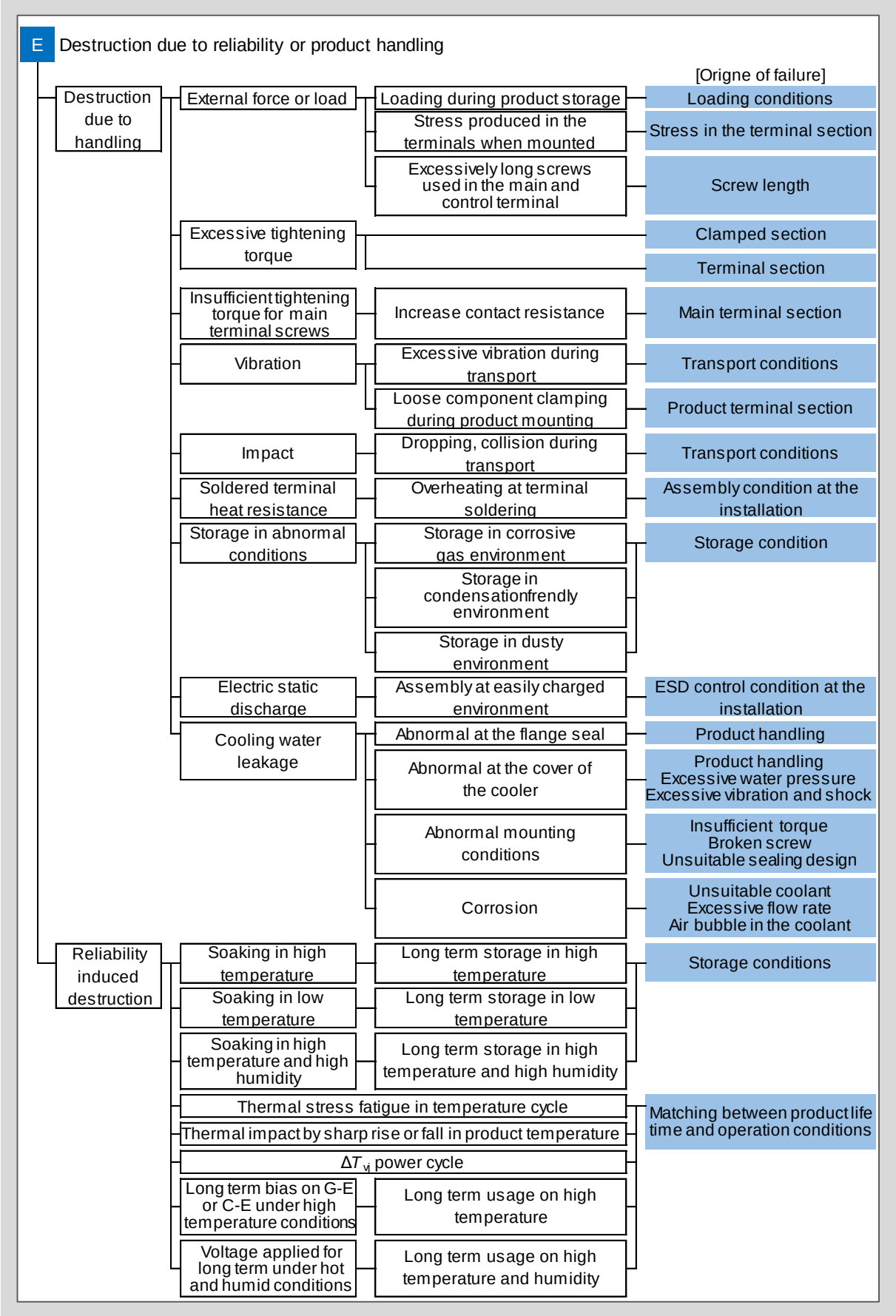

Fig. 4-1(f) Mode E: FWD destruction

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