Chapter 4 Troubleshooting

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 check point
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	Overheat	Integrity device t_{off} and dead time
			dead time setting mistakes		
		d*v*/d*t* malfunction	less reverse gate bias	SCSOA and/or overheat	Faulty turn-on due to d*v*/d*t*
			too long gate wiring		
		Noise induced	Gate circuit malfunction		confirm circuit malfunction
			Logic circuit malfunction		
	Output short-circuit	Faulty wiring, abnormal wire contact, load short-circuit			confirm failure phenomenon
	Ground short	Faulty wiring, abnormal wire contact,			Integrity between device ruggedness and protection condition
					Wiring conditions
Overload		Overcurrent	Logic circuit malfunction	Overheat	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 sunbber 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
					sunbber 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
			Electomagnetic 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 hundred nano second.

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	Check circuit design
			Too mach time constant of power supply settling		
			Gate wiring break		
Excessive gate voltage		Electro static discharge on V_{GE}		Excessive V_{GES}	Assembly earea 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
Overvoltege on temperature diode, sense IGBT		Temperature diode and/or sense IGBT destruction due to ESD		ESD	Assembly earea 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)

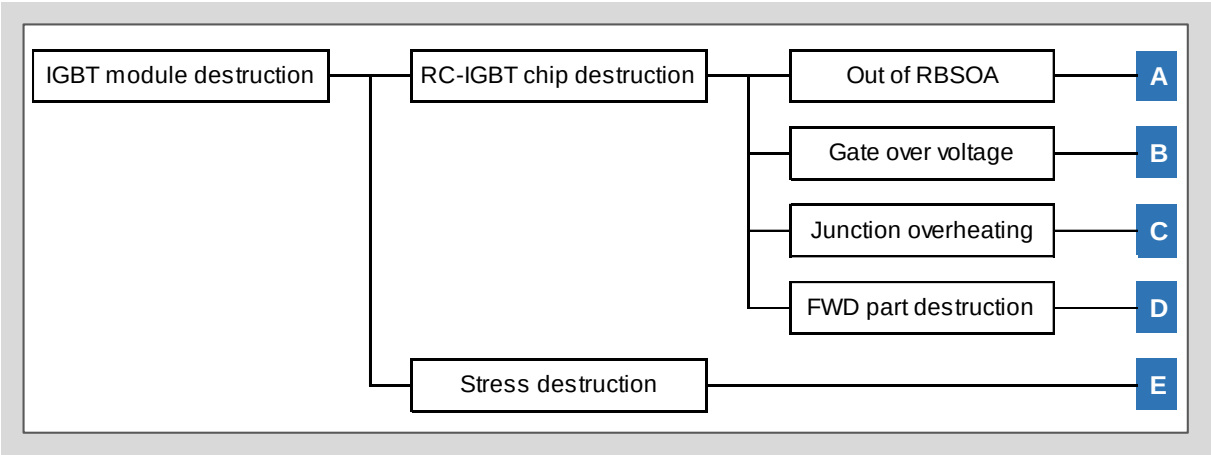

Fig. 4-1(a) IGBT module failure analysis

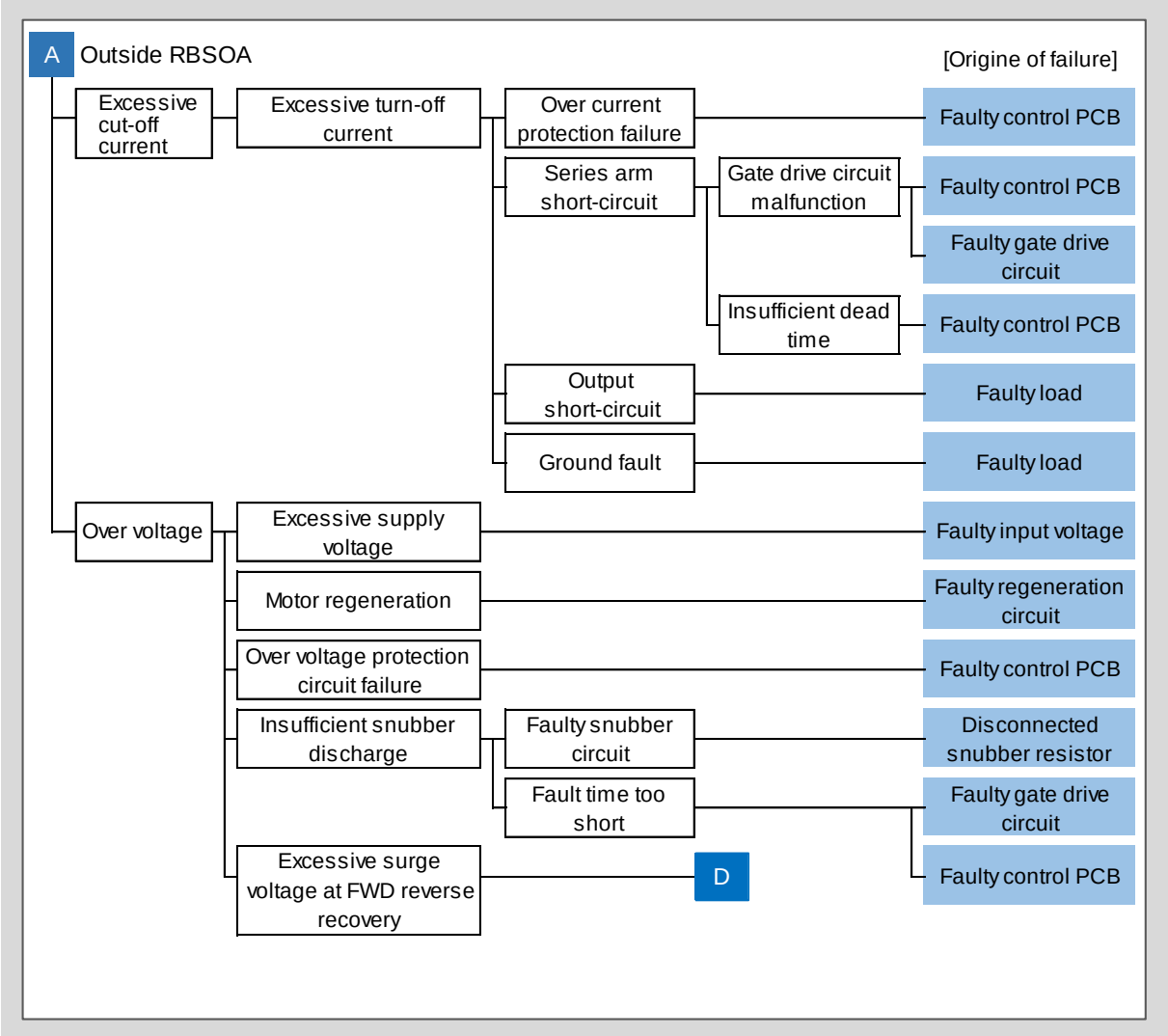

Fig. 4-1(b) Mode A: Outside RBSOA

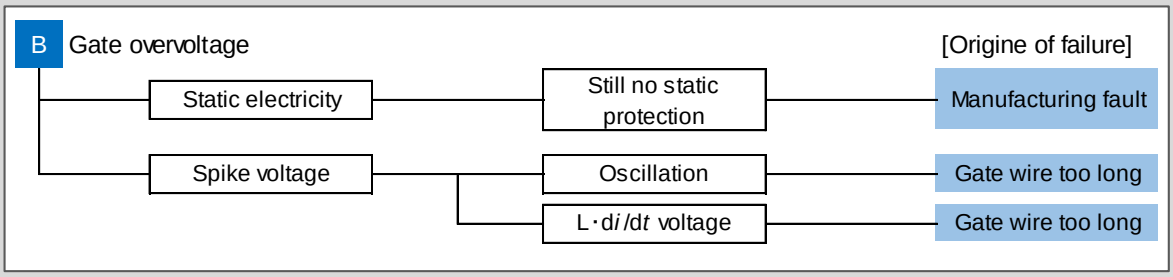

Fig. 4-1(c) Mode B: Gate overvoltage

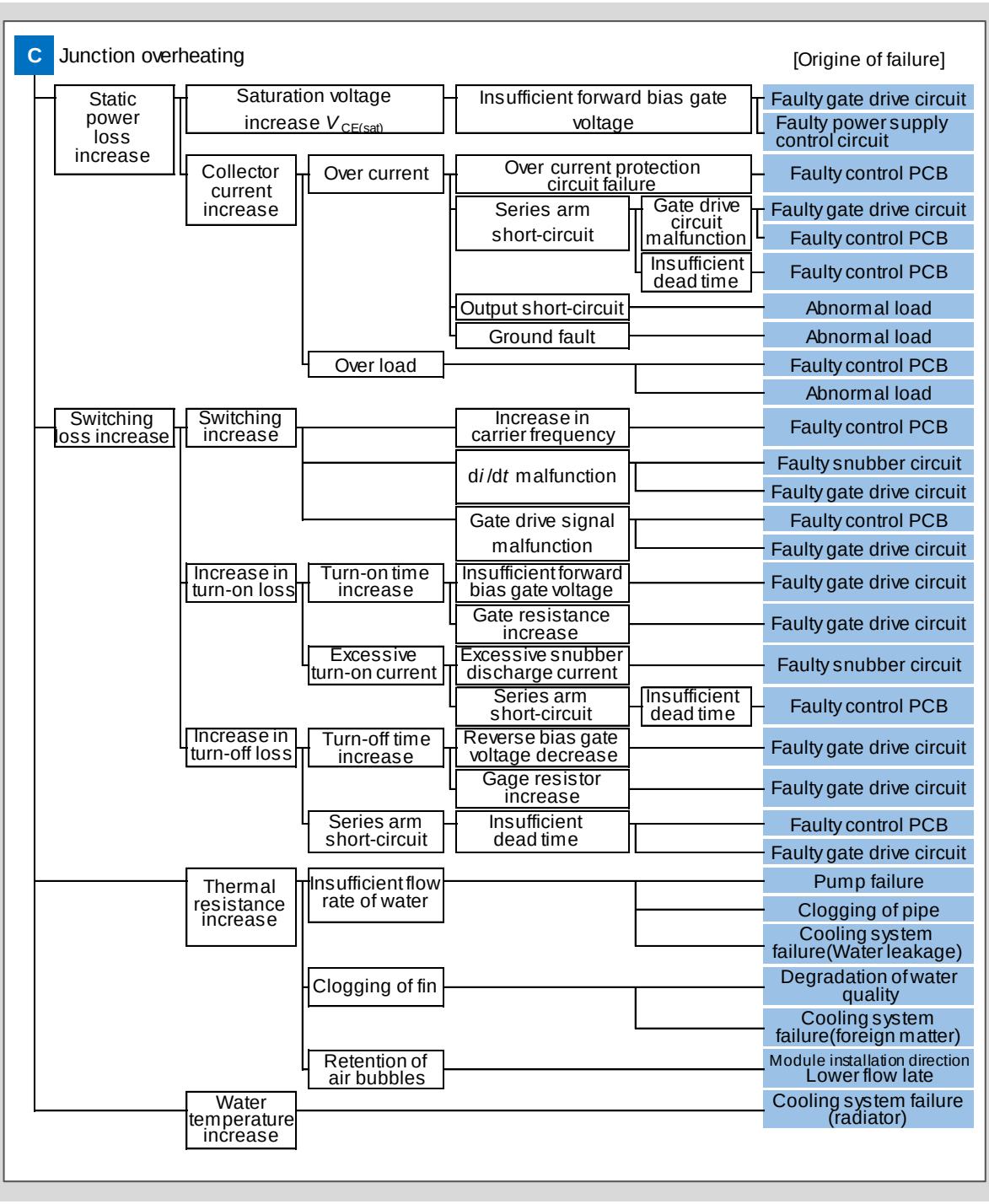

Fig. 4-1(d) Mode C: Junction over heating

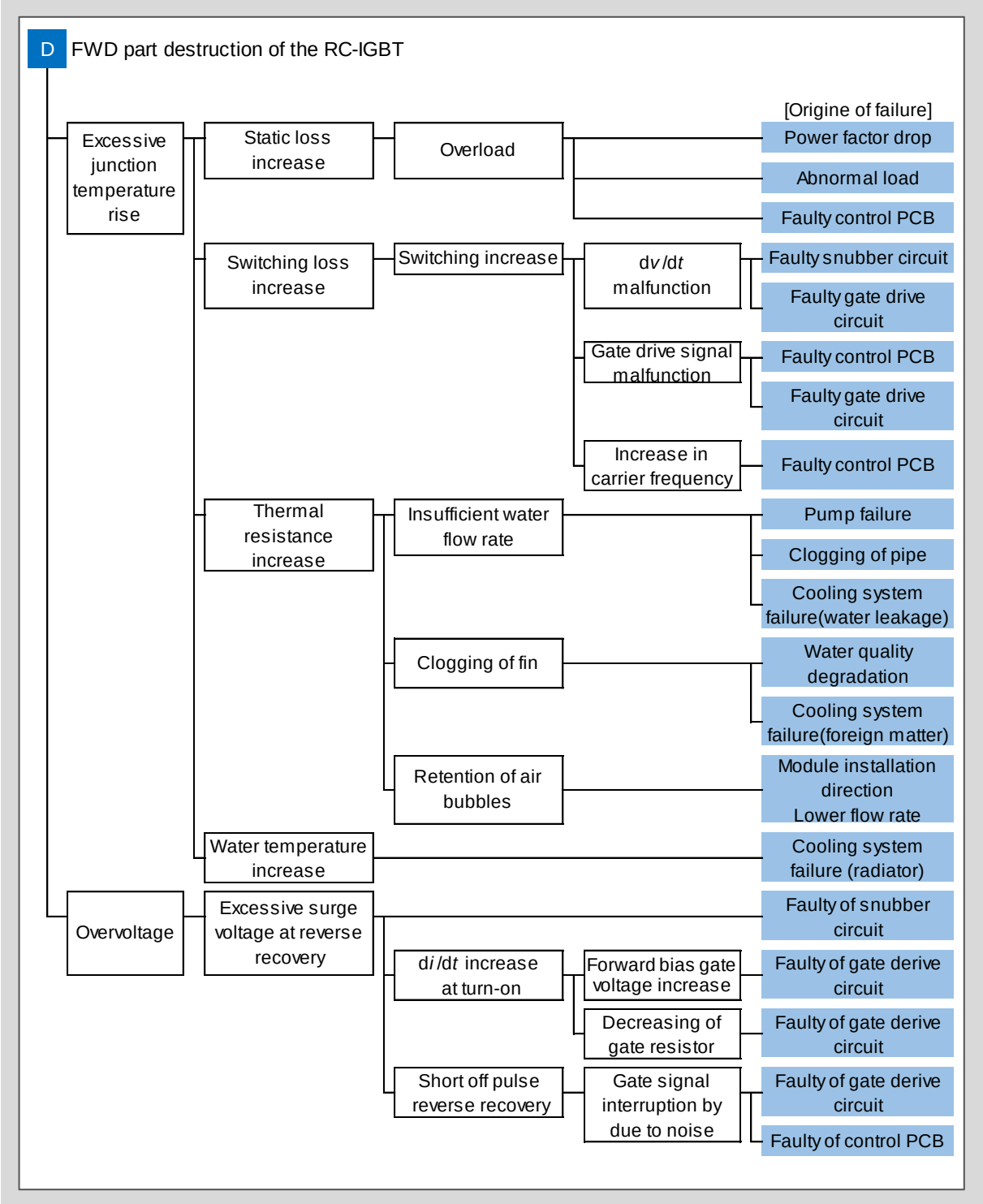

Fig. 4-1(e) Mode D: FWD destruction

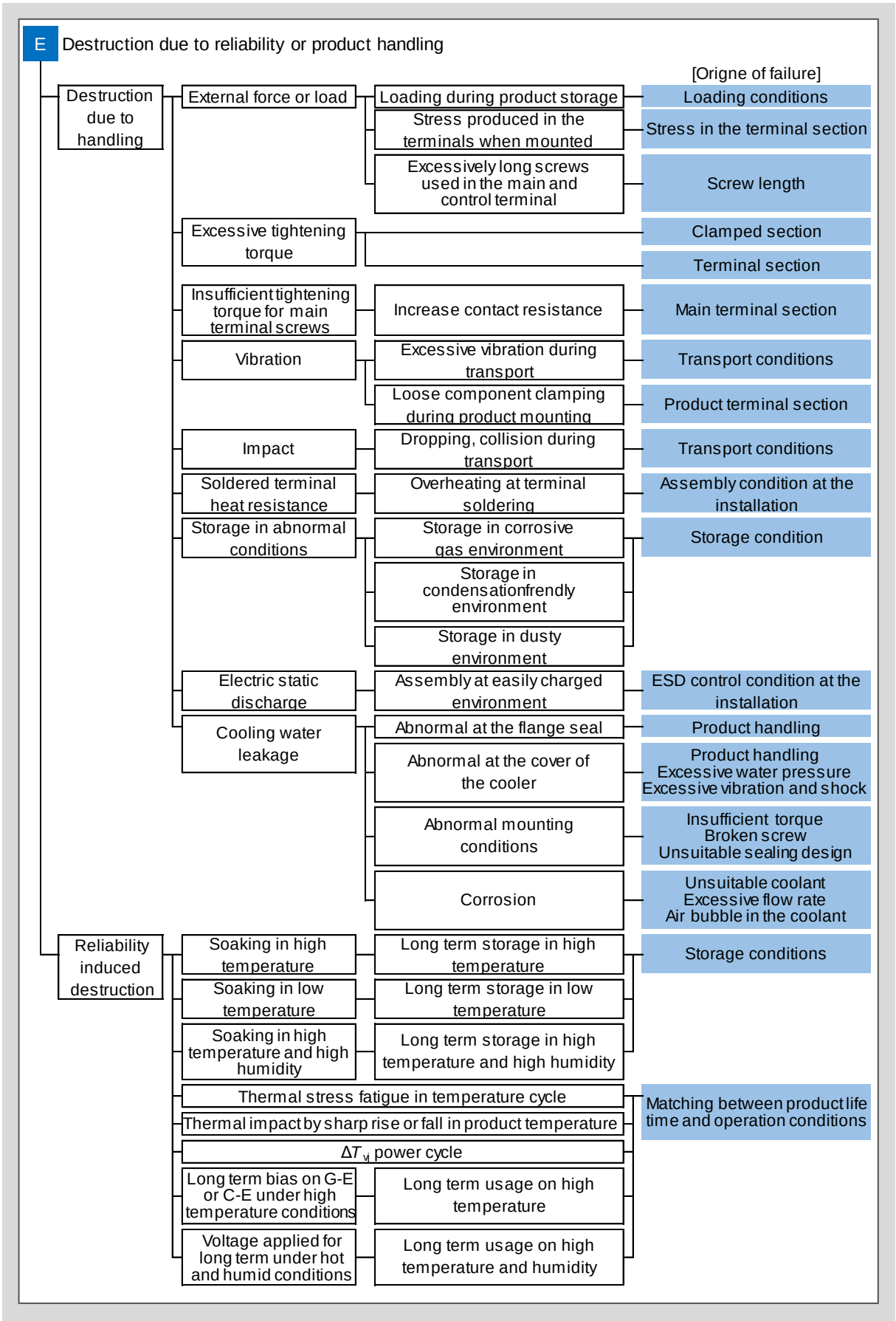

Fig. 4-1(f) Mode E: FWD destruction