

Contents

1 Introduction	7
1.1 Tokamak	10
1.2 Elongated plasma	11
1.3 Plasma stability	12
2 Disruptions	15
2.1 Disruptions	16
2.2 Vertical displacement event	18
2.3 Runaway electrons	21
2.3.1 Relativistic correction	23
2.3.2 Avalanche mechanism	24
2.4 Consequences of a disruption	26
2.4.1 Heat loads	26
2.4.2 Electromagnetic loads on the vessel	27
2.4.3 Runaway electrons	29
2.5 Disruption mitigation	30
2.5.1 Review of pellet injection experiments	30
2.5.2 Review of massive gas injection experiments	32
3 Experimental setup	37
3.1 Fast disruption mitigation valve	38
3.1.1 DMV principles	38
3.1.2 Test arrangement	40
3.1.3 Opening characteristics	41
3.1.4 Valve efficiency, throughput and decay rate.	43
3.1.5 DMV at TEXTOR	46
3.2 Ultra-fast framing camera	49
3.2.1 Camera tests	49
3.2.2 Fast camera at TEXTOR	51
3.3 Essential diagnostics and their limitations	53
3.3.1 Electron cyclotron emission (ECE)	53
3.3.2 Thomson scattering	53
3.3.3 Soft X-ray camera	55
3.3.4 Synchrotron emission	56
3.3.5 Neutron detectors	57
3.4 Position of the $q = 2$ flux surface	57
4 Experimental results	59
4.1 Predisruptive phase	60
4.1.1 Reconstruction of camera images	63
4.1.2 Fraction of injected gas	66
4.1.3 Interpretation of the emission front	67
4.1.4 Duration of the predisruptive phase	68
4.2 Thermal quench	70

4.2.1 Start of the thermal quench	70
4.2.2 Duration of thermal quench	72
4.2.3 Fast camera observations	75
4.2.4 Summary	78
4.3 Current quench	79
4.3.1 Current decay rate	79
4.3.2 Runaway electrons	80
4.3.3 Dynamics of the plasma column	82
5 Current quench model	85
5.1 Current channel size and contraction	89
5.2 Simulation of argon injection discharges	90
5.3 Sensitivity analysis	93
5.4 Simulation of mixture injection discharges	96
5.5 Simulation of helium injection discharges	97
5.6 Current decay rate	98
5.7 On the nature of runaway electrons suppression	98
6 Conclusions	101
A Plasma Stability	107
B On the kinetic equation for runaway electrons	109
B.1 Non-relativistic case	109
B.2 Collisions with impurities	112
B.3 Weak relativistic form	112
C ECE cut-off	115
D List of used symbols	119