Electricity (Safety) Regulations

- **Electricity (Safety) Regulation 33 states that any power or telecommunications construction must not cause any induced voltage or EPR that is LIKELY to cause danger to persons or damage to telecommunications plant**

- **Induced voltages that do not exceed**
  - **430V for durations > 0.5s (and ≤ 5s)**
  - **650V for durations ≤ 0.5s**

  are DEEMED not to be likely to cause a hazard to persons or damage to telecommunications plant

Hazard Assessment Options

1. Comply with the 430 V / 650 V ‘deemed to comply’ hazard voltage limits in ESR 33

2. Comply with other authoritative international Power Co-ordination hazard voltage limits (e.g. ITU-T Directives Vol. 6:2008)

3. **Comply with a (yet to be developed) authoritative NZ specific set of Power Co-ordination hazard voltage limits, calculated from IEC 60479-1:2005 on a similar basis to the limits in the EEA ‘Guide to Power System Earthing Practice’ 2009, and the ITU-T Directives Vol. 6:2008**

4. **Demonstrate by way of a Risk Analysis that the hazard is not likely to occur.**

IEC 60479-1:2005

- IEC 60479-1 ‘Effects of current on human beings and livestock, Part 1 General aspects’ is the ‘bible’ on electricity hazard to humans.
- The ITU-T Directives Vol. 6:2008 and the EEA ‘Guide to Power System Earthing Practice’ 2009, both calculate their human hazard voltage limits based on data from this IEC standard.

- The Electricity (Safety) Regulations 2010 specifically refer to this standard (as the ‘IEC shock currents standard’)
- Any future NZ specific set of Power Co-ordination human hazard voltage limits will similarly be calculated based on data from IEC 60479-1:2005 .
- IEC 60479-1:2005 is also published as AS/NZS 60479.1:2010.

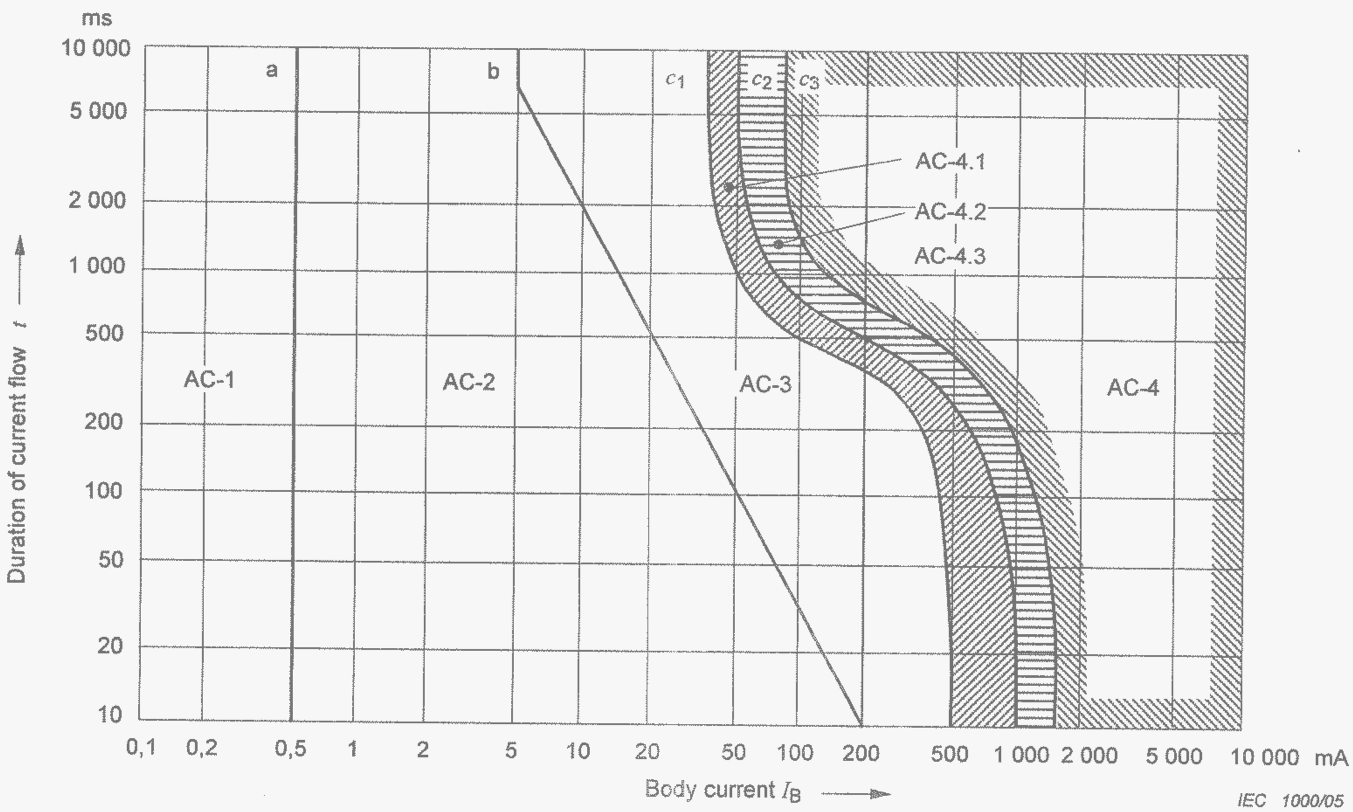


Figure 20 – Conventional time/current zones of effects of a.c. currents (15 Hz to 100 Hz) on persons for a current path corresponding to left hand to feet (for explanation see Table 11)

Table 11 – Time/current zones for a.c. 15 Hz to 100 Hz for hand to feet pathway – Summary of zones of Figure 20

Zones	Boundaries	Physiological effects
AC-1	Up to 0,5 mA curve a	Perception possible but usually no 'startled' reaction
AC-2	0,5 mA up to curve b	Perception and involuntary muscular contractions likely but usually no harmful electrical physiological effects
AC-3	Curve b and above	Strong involuntary muscular contractions. Difficulty in breathing. Reversible disturbances of heart function. Immobilization may occur. Effects increasing with current magnitude. Usually no organic damage to be expected
AC-4 [1)]	Above curve c_1	Patho-physiological effects may occur such as cardiac arrest, breathing arrest, and burns or other cellular damage. Probability of ventricular fibrillation increasing with current magnitude and time
	c_1-c_2	AC-4.1 Probability of ventricular fibrillation increasing up to about 5 %
	c_2-c_3	AC-4.2 Probability of ventricular fibrillation up to about 50 %
	Beyond curve c_3	AC-4.3 Probability of ventricular fibrillation above 50 %

1) For durations of current flow below 200 ms, ventricular fibrillation is only initiated within the vulnerable period if the relevant thresholds are surpassed. As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path left hand to feet. For other current paths, the heart current factor has to be considered.

Table 12 – Heart-current factor F for different current paths

Current path	Heart-current factor F
Left hand to left foot, right foot or both feet	1,0
Both hands to both feet	1,0
Left hand to right hand	0,4
Right hand to left foot, right foot or to both feet	0,8
Back to right hand	0,3
Back to left hand	0,7
Chest to right hand	1,3
Chest to left hand	1,5
Seat to left hand, right hand or to both hands	0,7
Left foot to right foot	0,04

EXAMPLE A current of 225 mA hand to hand has the same likelihood of producing ventricular fibrillation as a current of 90 mA left hand to both feet.

Table 1 – Total body impedances Z_T for a current path hand to hand a.c. 50/60 Hz, for large surface areas of contact in dry conditions

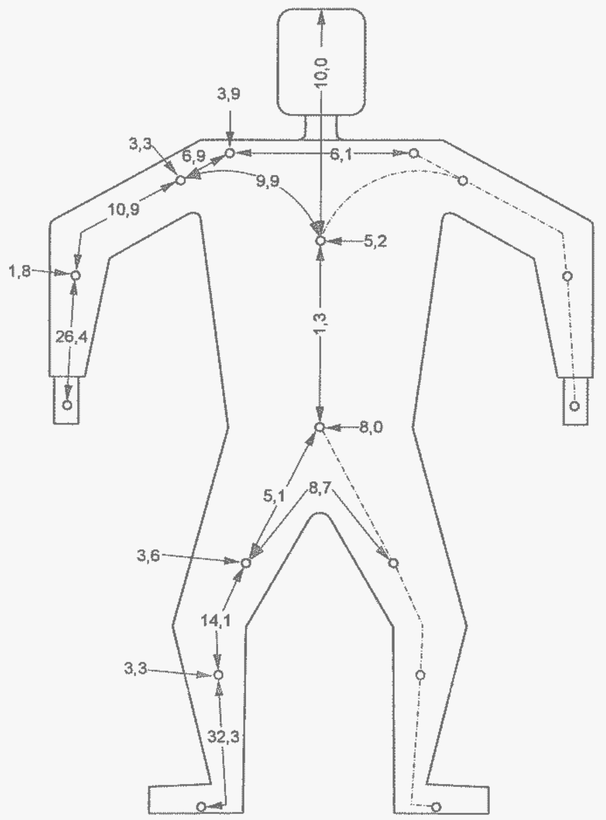
Touch voltage V	Values for the total body impedances Z_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	1 750	3 250	6 100
50	1 375	2 500	4 600
75	1 125	2 000	3 600
100	990	1 725	3 125
125	900	1 550	2 675
150	850	1 400	2 350
175	825	1 325	2 175
200	800	1 275	2 050
225	775	1 225	1 900
400	700	950	1 275
500	625	850	1 150
700	575	775	1 050
1 000	575	775	1 050
Asymptotic value = internal impedance	575	775	1 050

NOTE 1 Some measurements indicate that the total body impedance for the current path hand to foot is somewhat lower than for a current path hand to hand (10 % to 30 %).

NOTE 2 For living persons the values of Z_T correspond to a duration of current flow of about 0,1 s. For longer durations Z_T values may decrease (about 10 % to 20 %) and after complete rupture of the skin Z_T approaches the internal body impedance Z_i.

NOTE 3 For the standard value of the voltage 230 V (network-system 3N ~ 230/400 V) it may be assumed that the values of the total body impedance are the same as for a touch voltage of 225 V.

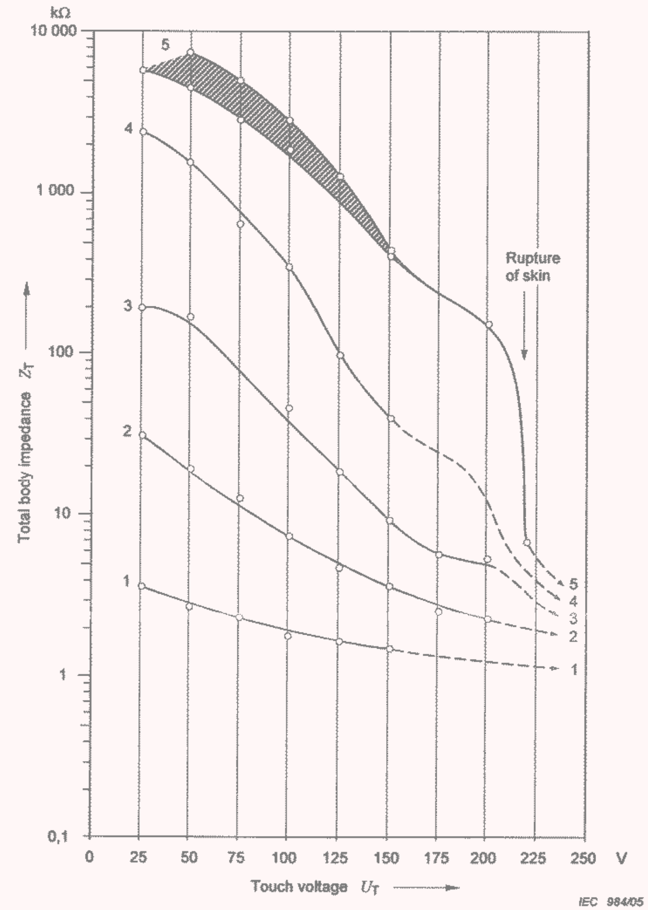
NOTE 4 Values of Z_T are rounded to 25 Ω.



The numbers indicate the percentage of the internal impedance of the human body for the part of the body concerned, in relation to the path hand to foot.

NOTE In order to calculate the total body impedance Z_T for a given current path, the internal partial impedances Z_{ip} for all parts of the body of the current path have to be added as well as the impedances of the skin of the surface areas of contact. The numbers outside the body show internal portions of the impedance to be added to the total, when the current enters at that point.

Figure 2 – Internal partial impedances Z_{ip} of the human body



Key

(For further details, see Annex D)

1 Surface area of contact 8200 mm²

2 Surface area of contact 1250 mm²

3 Surface area of contact 100 mm²

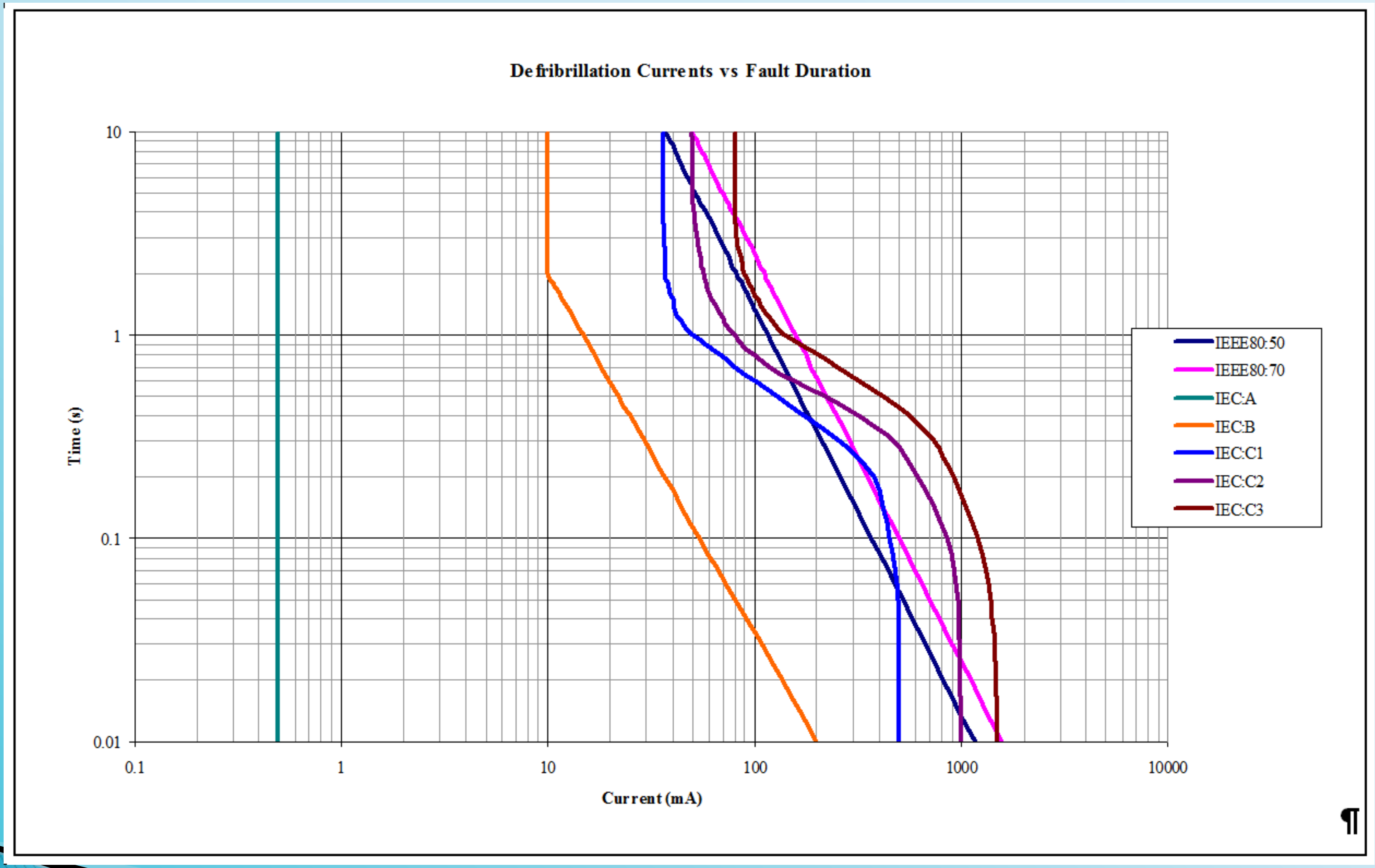
4 Surface area of contact 10 mm²

5 Surface area of contact 1 mm²

(Breakdown of the skin at 220 V)

Figure 5 – Dependence of the total impedance Z_T of one living person on the surface area of contact in dry condition and at touch voltage (50 Hz)

Comparison with IEEE body current curves



ITU-T Directives Hazard Limits

Fault Duration (s)	ITU-T Directives (V)	NZ ESR 33 (V)	Australia (V)	Japan (V)
$t \le 0.2$	1,030	650	1,500	430
$0.2 < t \le 0.35$	780			300
$0.35 < t \le 0.5$	650		1,000	
$0.5 < t \le 1.0$	430	430	430	
$1.0 < t \le 3.0$	150			
$3.0 < t \le 5.0$	60			
$t > 5.0$		60	60	60

Risk Analysis

Equivalent Probability (per annum)	Risk Classification for Individual Death	Resulting Implication for Hazard Mitigation
$> 10^{-4}$	High	Intolerable Must prevent occurrence regardless of cost
10^{-4} - 10^{-6}	Intermediate	ALARP for Intermediate Risk Must minimise occurrence unless risk reduction is impractical and costs are grossly disproportionate to safety gained
$< 10^{-6}$	Low	ALARP for Low Risk Minimise occurrence if reasonably practical and cost of reduction is reasonable

- Use of calculated risk levels to justify a possible hazard situation is still a relatively new approach in the NZ power industry
- Quality of risk data is very variable
- Probability values used are also very variable
- This presents challenges – new area

- **These voltage limit and risk analysis issues are currently under discussion between the Power and Telecommunications industries in NZ**
- **The results will be detailed in the future NZCCPTS Hazard Assessment Guide (2013?)**
- **This guide will include Risk Analysis case studies in the Appendices**