Intrinsic Safety Equations

This appendix provides the equations that the software uses to calculate maximum permissible cable length for areas that require intrinsic safety. The chapters of this appendix are the following:

1. Nomenclature

C	Capacitance
C_fact	Capacitance factor (capacitance/length), as defined in the **Intrinsically Safe Data Input** dialog box
Cable A	Cable that connects the junction box (hazardous area) with the marshaling rack (non-hazardous area)
Cable B	Within the hazardous area, cable that connects the field device with the junction box
cables	All cables A and B
$COEFF_{cable\ x}$	For a given cable type, the coefficient for resistance, inductance, or capacitance (used in the Intrinsically Safe Circuit Report)
haz_tag	Hazardous area field instrument parameter
L	Inductance
L_fact	Inductance factor (inductance/length), as defined in the **Intrinsically Safe Data Input** dialog box

max_	Maximum permissible value
R	Resistance
R_fact	Resistance factor (resistance/length), as defined in the **Intrinsically Safe Data Input** dialog box
safety	Non-hazardous area safety device parameter

2. Intrinsic Safety Calculation by Circuit Type

To initiate an intrinsic safety calculation by circuit type, in the **Wiring Module** window, on the **Associations** menu, click **Intrinsic Safety**. For details, see Calculating Intrinsic Safety, in the Wiring chapter.

2.1 Assumptions

The intrinsic safety calculation considers the following values, all of which you enter in the **Intrinsically Safe Data Input** dialog box:

- The parameters of the hazardous area field device: $R_{haz\ tag}$, $L_{haz\ tag}$, and $C_{haz\ tag}$.
- The parameters of the safety device in the non-hazardous area: R_{safety}, L_{safety}, and C_{safety}.
- Parameters associated with cables:
  - $R\_fact_{Cable\ A}$, $L\_fact_{Cable\ A}$, and $C\_fact_{Cable\ A}$
  - $R\_fact_{Cable\ B}$, $L\_fact_{Cable\ B}$, and $C\_fact_{Cable\ B}$
  - $Length_{Cable\ B}$

2.2 Calculating Maximum Permissible Length of Cable A

For the circuit type that you selected, the software calculates the maximum permissible length of Cable A – the cable that connects the hazardous area with the non-hazardous area. The calculations are all based on the requirement that the total load of a given parameter (resistance, inductance, or capacitance) may not exceed the ability of the safety device to control the load.

2.2.1 Resistance

$$R_{haz\_tag} + R_{CableA} + R_{CableB} < R_{safety}$$

$$R_{\max\_cables} = R_{CableA} + R_{CableB}$$

$$R_{\max\_cables} < R_{safety} - R_{haz\_tag}$$

$$R_{CableB} = R\_fact_{CableB} * Length_{CableB}$$

$$\max\_length\_R_{CableA} = \frac{R_{\max\_cables} - R_{CableB}}{R\_fact_{CableA}} = \frac{R_{CableA}}{R\_fact_{CableA}}$$

2.2.2 Inductance

$$L_{haz\_tag} + L_{CableA} + L_{CableB} < L_{safety}$$

$$L_{\max\_cables} = L_{CableA} + L_{CableB}$$

$$L_{\max\_cables} < L_{safety} - L_{haz\_tag}$$

$$L_{CableB} = L\_fact_{CableB} * Length_{CableB}$$

$$\max\_length\_L_{CableA} = \frac{L_{\max\_cables} - L_{CableB}}{L\_fact_{CableA}} = \frac{L_{CableA}}{L\_fact_{CableA}}$$

2.2.3 Capacitance

$$C_{haz\_tag} + C_{CableA} + C_{CableB} < C_{safety}$$

$$C_{\max\_cables} = C_{CableA} + C_{CableB}$$

$$C_{\max\_cables} < C_{safety} - C_{haz\_tag}$$

$$C_{CableB} = C\_fact_{CableB} * Length_{CableB}$$

$$\max\_length\_C_{CableA} = \frac{C_{\max\_cables} - C_{CableB}}{C\_fact_{CableA}} = \frac{C_{CableA}}{C\_fact_{CableA}}$$

2.2.4 Maximum Permissible Length for Cable A

The software then sets the minimum among the maximum lengths calculated by R_fact, L_fact, and C_fact as the maximum permissible length for Cable A.

2.2.5 L/R Limitation

The intrinsic safety report also allows you to verify visually that the total of the L/R factor for Cables A and B does not exceed the L/R protection of the isolator safety device. To include cable L/R factor in a pass/fail calculation, see Instrinsic Safety Calculation by Loop.

3. Intrinsic Safety Calculation by Loop

To initiate an intrinsic safety calculation by loop, in the **Wiring Module** window, on the **Associations** menu, click **Intrinsic Safety Loop Calculation**. For details, see Calculating Intrinsic Safety for a Loop, in the Wiring chapter. For a summary of the differences between intrinsic safety (IS) calculation by circuit type and by loop, see the following table:

Feature	By Circuit Type	By Loop
Level	Circuit type	For all the tags in a loop
Cables	One Cable A and one Cable B	All cables in the circuit for which the IS check box is selected
Parameters Considered	Resistance Inductance Capacitance	Resistance Inductance Capacitance L/R
Result	Maximum permissible length of Cable A parameter that limits length	Pass / fail for all tags associated with an IS circuit type
Report	Full diagram with calculation results; Calculation explanation	Instrument & barrier safety characteristics; List of IS cables and their characteristics; If Pass, calculated results, including $(L/R)_{cables}$

3.1 Assumptions

For each tag in a loop, the intrinsic safety calculation considers the following values:

- The parameters of the hazardous area field device: $R_{haz\ tag}$, $L_{haz\ tag}$, and $C_{haz\ tag}$.
- The parameters of the safety device in the non-hazardous area: R_{safety}, L_{safety}, C_{safety}, and L/R_{safety}.
- Parameters associated with $Cable_{i\ (i= 1, 2, \ \ldots\ n)}$. Note that there is no limit on the number of cables, and the cables can be connected serially or in parallel.
    - $R\_fact_{Cable\ i}$, $L\_fact_{Cable\ i}$, and $C\_fact_{Cable\ i}$, all of which are determined by the cable type.
    - $Length_{Cable\ I}$

3.2 Calculating Cable Parameter Values

For each cable, the software calculates the following values:

$$R_{Cable\_i} = R\_fact_{Cable\_i} * Length_{Cable\_i}$$

$$L_{Cable\_i} = L\_fact_{Cable\_i} * Length_{Cable\_i}$$

$$C_{Cable\_i} = C\_fact_{Cable\_i} * Length_{Cable\_i}$$

$$(\frac{L}{R})_{Cable\_i} = \frac{L_{Cable\_i}}{R_{Cable\_i}}$$

3.3 Determining if a Circuit is Intrinsically Safe

For each tag in the loop, if all of the following are true, the software certifies the tag circuit as intrinsically safe:

$$R_{haz\_tag} + R_{Cable1} + R_{Cable2} + ... + R_{Cable\_n} < R_{safety}$$

$$L_{haz\_tag} + L_{Cable1} + L_{Cable2} + ... + L_{Cable\_n} < L_{safety}$$

$$C_{haz\_tag} + C_{Cable1} + C_{Cable2} + ... + C_{Cable\_n} < C_{safety}$$

$$(\frac{L}{R})_{Cable1} + (\frac{L}{R})_{Cable2} + ... + (\frac{L}{R})_{Cable\_n} < (\frac{L}{R})_{safety}$$