# APPENDIX F: AGGREGATION RULES FOR THE DETERMINATION OF CHARACTERISTIC CONTAINMENT SIZE IN A LUMPED-PARAMETER APPROACH*

## F.1 Description of the Rules

A description of the control volumes of a French pressurized-water reactor (PWR) 900 MWe has been used to define the present geometrical parameters. The rooms have four different shapes (Figure F.1-1): most of them can be assumed to be cubic but in the lower part flat and tall volumes are present, and the annular gap is mainly characterized by long rooms.

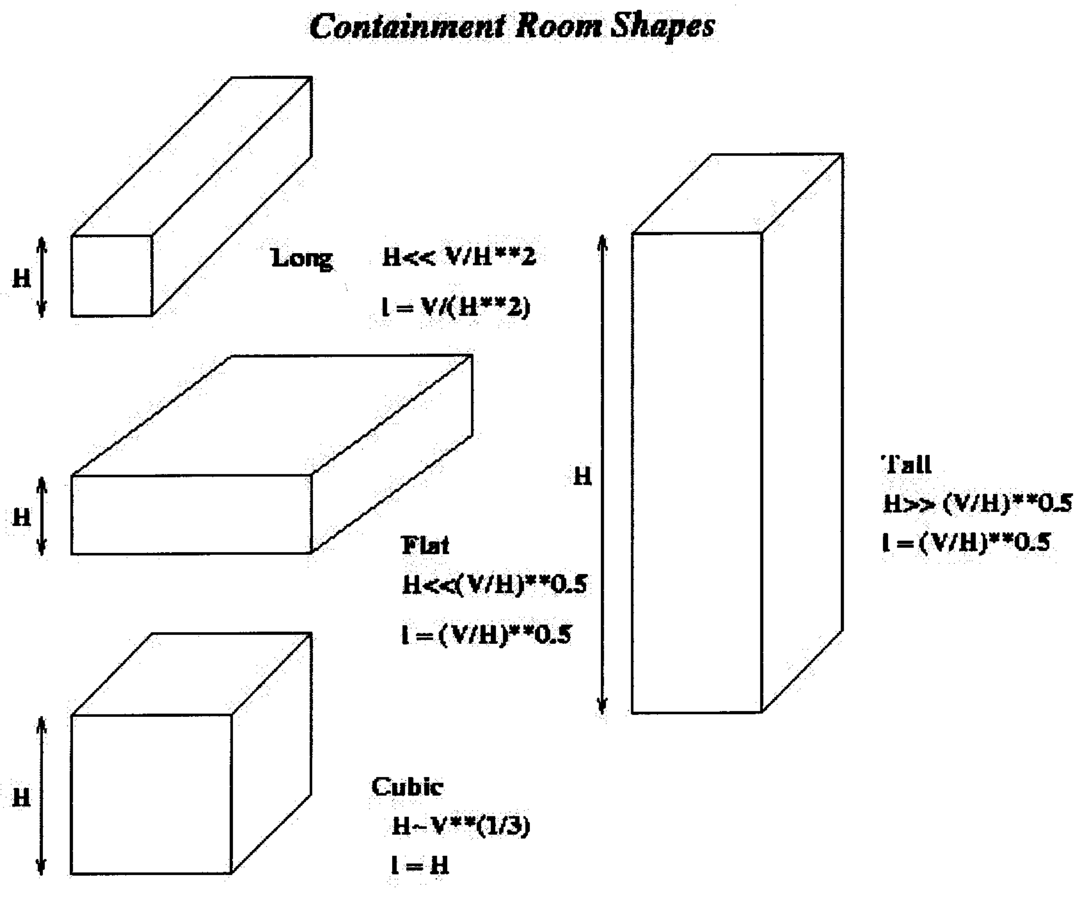


**Figure F.1-1: Containment room shapes**

Using these shapes, the characteristic length, L, of a single compartment can be defined, as described in Figure F.1-2. Long rooms can have significant size openings, and we have chosen to add a porosity factor, β, to calculate the characteristic size of such a room.

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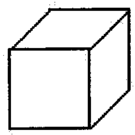
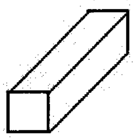
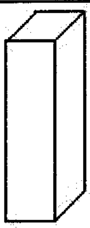
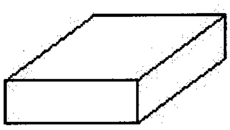
* Mr. Etienne Studer is the lead author for Appendix F.

## *Compartment Characteristic Size*

**V: compartment volume**
**H: compartment height**

| **Shape** | **Characteristic Size L** |
|---|---|
|  | $L = \sqrt[3]{V}$ |
|  | $l = V/(H.H)$<br>$L = (l+H)/2$ |
|  | $l = \sqrt{V/H}$<br>$L = (l+H)/2$ |
|  | $L = \sqrt{V/H}$ |

**Effect of openings for long and tall shapes:**

$\beta = 1. - Sc/(Sc+Sw)$ **and** $L = (H + (H + \beta^2 (l - H)))/2.$

**Figure F.1-2: Characteristic room size**

According to these hypotheses, the blockage factor, $\alpha_i$, can be calculated using different junction types (Figure F.1-3). Other formulations can be derived using the assumed shapes and the $\phi$ parameter, for example. The first step is to propose a formula, and investigation of different formulas can be made during the performance of the sensitivity analysis.

## *Compartment Junction Rules*

**V: compartment volume**
**H: compartment height**
**s: junction area**
**Φ: total wall and junction area**

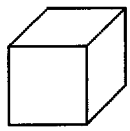
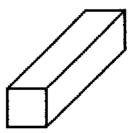
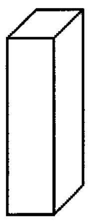
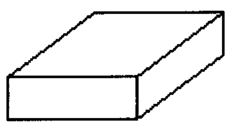
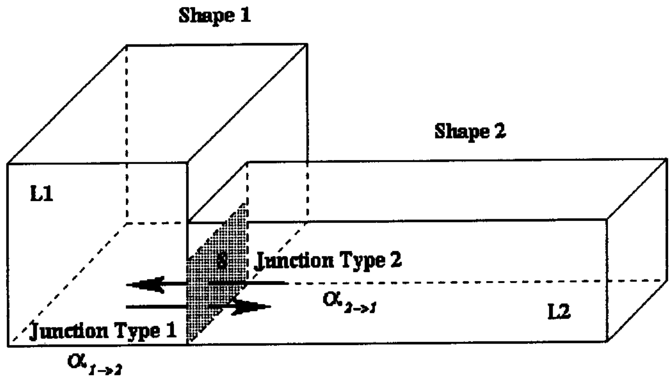
| Shape | Junction Type | Blockage α |
|---|---|---|
|  | side | $\sqrt{\frac{H.s}{V}}$ or $\sqrt{\frac{6.s}{\Phi}}$ |
|  | end<br>side | $\sqrt{\frac{s}{H.H}}$<br>$\sqrt{\frac{H.s}{V}}$ |
|  | bottom or top<br>side | $\sqrt{\frac{s}{H.H}}$<br>$\sqrt{\frac{s}{\sqrt{V.H}}}$ |
|  | bottom or top<br>side | $\sqrt{\frac{H.s}{V}}$<br>$\sqrt{\frac{s}{\sqrt{V.H}}}$ |

**Figure F.1-3: Room blockage parameter**

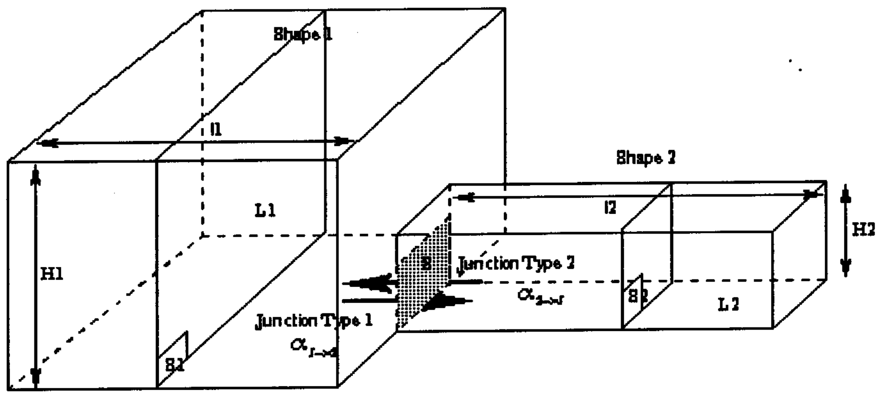
Regarding the system of connected rooms, direct application of the proposed formula (Chapter 3) leads to very large and unrealistic characteristic length L. Thus aggregation rules have been derived for all the possible cases. The bases of these rules are as follows:

- For a single flame path (Figure F.1-4), the proposed formula is used with an upper limit corresponding to a concatenation of the two volumes (a special case is considered when the two connecting rooms have very different characteristic sizes and the contribution depends on the acceleration potential of the flame).
- For a multiple flame path (Figure F.1-4), the contribution is limited by a "limiting" length equal generally to the minimum geometrical size perpendicular to the junction (this reduces the contribution of connected rooms according to multiple flame paths).

*Aggregation rules : Definitions*




***Aggregation rules : Comments***




**If one single flame path :**

**If size1 ~ size 2:**

$L(2) = L2 + \alpha_{2\to1}\ L1$

$L(1) = L1 + \alpha_{1\to2}\ L2$

with $\alpha = \min(\alpha, 0.5)$

**If size 1 >> size 2:**

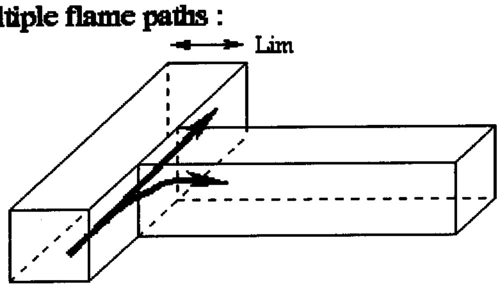
expansion = slow down
restriction = acceleration

$\beta = S1 / S2$

$L(1) = L1 + \alpha_{1\to2} L2\ \beta$

$L(2) = L2 + \alpha_{2\to1} L1 / \beta$

**If multiple flame paths :**



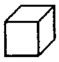
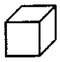
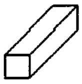
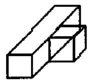
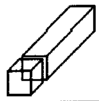
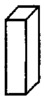

**Definition of a limiting Length: Lim**

$L(2) = L2 + \alpha_{2\to1}\ Lim$

$L(1) = L1 + \alpha_{1\to2}\ Lim$

**Figure F.1-4: Aggregation definitions and comments**

Using these definitions and basic considerations, the following rules (Figure F.1-5) have been used to calculate the characteristic size of a containment room.

<table>
<tr><th>Shape 1</th><th>Shape 2</th><th>Junction Type 1</th><th>Junction Type 2</th><th colspan="3">Rules</th></tr>
<tr><td></td><td></td><td>side</td><td>side</td><td></td><td>L1~L2<br>$L(1) = L1 + \alpha L2$<br>$L(2) = L2 + \alpha L1$<br>with $\alpha = \min(\alpha, 0.5)$</td><td>L1>>L2<br>$\beta = H1.H1/(H2.H2)$<br>$L(1) = L1 + \alpha L2\beta$<br>$L(2) = L2 + \alpha L1/\beta$</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">side</td><td>side</td><td></td><td>$lmin = \min(H1, H2)$<br>$L(1) = L1 + \alpha\ lmin$</td><td>$L(2) = L2 + \alpha\ lmin$</td></tr>
<tr><td>end</td><td></td><td>H1~H2<br>$L(1) = L1 + \alpha L2$<br>$L(2) = L2 + \alpha L1$<br>with $\alpha = \min(\alpha, 0.5)$</td><td>H1>>H2<br>$\beta = H1.H1/(H2.H2)$<br>$L(1) = L1 + \alpha L2\ \beta$<br>$L(2) = L2 + \alpha L1/\ \beta$</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">side</td><td>side</td><td></td><td>$lmin = \min(H1, l2)$<br>$L(1) = L1 + \alpha\ lmin$</td><td>$L(2) = L2 + \alpha\ lmin$</td></tr>
<tr><td>bottom or top</td><td></td><td>H1~l2<br>$L(1) = L1 + \alpha L2$<br>$L(2) = L2 + \alpha L1$<br>with $\alpha = \min(\alpha, 0.5)$</td><td>H1>>l2<br>$\beta = H1.H1/(l2.l2)$<br>$L(1) = L1 + \alpha L2\ \beta$<br>$L(2) = L2 + \alpha L1/\ \beta$</td></tr>
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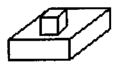
<tr><td>bottom or top</td><td></td><td>H1~l2<br>$L(1) = L1 + \alpha L2$<br>$L(2) = L2 + \alpha L1$<br>with $\alpha = \min(\alpha, 0.5)$</td><td>H1>>l2<br>$\beta = H1.H1/(l2.l2)$<br>$L(1) = L1 + \alpha L2\ \beta$<br>$L(2) = L2 + \alpha L1/\ \beta$</td></tr>
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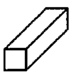
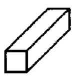
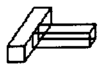
<tr><td rowspan="9"></td><td rowspan="3"></td><td rowspan="2">side</td><td>side</td><td></td><td colspan="2">$L(2) = L2 + \alpha H1$<br>$L(1) = L1 + \alpha H2$</td></tr>
<tr><td>end</td><td></td><td colspan="2">$lmin = \min(H1,H2)$<br>$L(2) = L2 + \alpha\ lmin$<br>$L(1) = L1 + \alpha\ lmin$</td></tr>
<tr><td>end</td><td>end</td><td></td><td>H1~H2 $L(2) = L2 + \alpha L1$<br>$L(1) = L1 + \alpha L2$<br>$\alpha = \min(\alpha, 0.5)$</td><td>H1>>H2 $\beta = H1.H1/(H2.H2)$<br>$L(2) = L2 + \alpha L1/\beta$<br>$L(1) = L1 + \alpha L2\ \beta$</td></tr>
<tr><td rowspan="3"></td><td rowspan="2">side</td><td>side</td><td></td><td colspan="2">$lmin = \min(H1,l2)$<br>$L(2) = L2 + \alpha\ lmin$<br>$L(1) = L1 + \alpha\ lmin$</td></tr>
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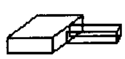
<tr><td>end</td><td>side</td><td></td><td>l2 is always >> H1</td><td>$lmin = \min(H1,H2)$<br>$L(2) = L2 + \alpha\ lmin$<br>$L(1) = L1 + \alpha\ lmin$</td></tr>
</table>

| *Shape 1* | *Shape 2* | *Junction Type 1* | *Junction Type 2* | *Rules* |
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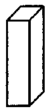
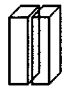
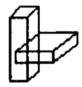
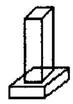
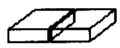
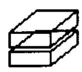
|  |  | **side** | **side** |  L(1)=L1 + α l2<br>L(2)=L2 + α l1<br>α = min( α, 0.5) |
| | | **bottom or top** | **bottom or top** |  l1~l2<br>L(1)=L1 + α L2<br>L(2)=L2 + α L1<br>α = min( α, 0.5)<br>l1>> l2<br>β = l1.l1/(l2.l2)<br>L(1) = L1 + α L2/β<br>L(2) = L2 + α L1 β |
| |  | **side** | **side** |  lmin = min ( l1,H2 )<br>L(1) = L1 + α lmin<br>L(2) = L2 + α lmin |
| | | **bottom or top** | **bottom or top** |  l2 is always >> l1<br>lmin = min ( l1,H2 )<br>L(1) = L1 + α lmin<br>L(2) = L2 + α lmin |
|  |  | **side** | **side** |  l1~l2 L(1) = L1 + α L2<br>L(2) = L2 + α L1<br>α = min ( α , 0.5 )<br>l1>> l2 β = l1.H1/(l2.H2)<br>L(1) = L1 + α L2/β<br>L(2) = L2 + α L1 β |
| | | **bottom or top** | **bottom or top** |  L(1) = L1 + α H2<br>L(2) = L2 + α H1<br>α = min ( α , 0.5 ) |

**Figure F.1-5: Aggregation rules for lumped-parameter approach**