

Appendix 2A ARCON96 Source/Receptor Inputs

2A.1 Scope

This appendix provides ARCON96 source/receptor inputs for use in the confirmation of site-specific X/Q values per 10 CFR 52.79 (as required by COL 2.0-1-A).

2A.2 Methodology

On-site X/Q values, such as those for the Control Room, are typically determined using the ARCON96 computer code. Acceptable guidance and methodology for use with ARCON96 are documented in Regulatory Guide (RG) 1.194 ([Reference 2A-1](#)). In order to determine bounding X/Q values, various nuclear plant sites have provided GE Hitachi Nuclear Energy (GEH) with the meteorological data in the required ARCON96 format. Additionally, raw meteorological data was obtained for sites pursuing early site permits. Control Room X/Q values were calculated with the ARCON96 computer code using the ESBWR plant layout and the available site meteorological data. Once completed, the results were reviewed and the X/Q values provided in [Table 2.0-1](#) were selected to bound those results.

2A.2.1 Meteorological Data

The meteorological data sets used as ARCON96 inputs for the ESBWR X/Q determination were taken from various published meteorological data sets. ARCON96 also requires the height of the instruments used for input in conjunction with the meteorological data. The heights of the upper and lower instruments used to record the raw data are unique to any meteorological data set taken at a nuclear power site. [Instrumentation heights used in the analysis are described in Subsection 2.3.3.1.1 Meteorological data from 2001 through 2007 and 1985 through 1989 is used in the analysis.](#)

2A.2.2 ARCON96 Default Values

Many of the ARCON96 inputs used for the determination were constant for each plant site evaluated. [Table 2A-1](#) provides a list of the standard ARCON96 inputs applicable for the ESBWR that are constant for all the source receptor pairs evaluated.

2A.2.3 ARCON96 ESBWR Inputs

[Table 2A-2](#) provides a list of the onsite receptor and source locations considered. [Table 2A-3](#) provides the ARCON96 inputs that are specific for ESBWR. The values presented in [Table 2A-3](#) have been determined in accordance with RG 1.194 and are described as follows. The values provided in [Table 2A-4](#) are the ARCON96 inputs for directions from the receptors to the sources in degrees from ESBWR Plant North. [These directions are adjusted by the difference in angle](#)

(approximately 19 degrees counterclockwise) between the true north and the Fermi 3 plant north; Fermi 3 receptor to source directions are shown in [Table 2A-4](#) analysis.

Source Type

Indication of whether the source associated with a line item in [Table 2A-1](#) should be considered a point source or a diffuse source. This has been determined based on the nature of the postulated releases in accordance with RG 1.194.

Distance

These distances are the source-to-receptor distances and are the shortest horizontal distances between the release points and the intakes.

Release Height

For diffuse sources in [Table 2A-3](#), the release height is set at the vertical center of the projected diffuse source plane above grade. For point sources the release heights are taken to be the vertical distance from finished ground level grade to the center of the release points.

Building Area

Areas are provided for the buildings that have the largest impact on the building wakes within the wind direction window for a given source/receptor pair.

Intake Height

The actual intake heights are provided in [Table 2A-3](#), and are taken to be the vertical distance from finished ground level grade to the center of the intakes.

Total Height

The total heights are the above grade heights of the buildings where diffuse sources are modeled. Building heights are not directly used by ARCON96. They are used to calculate the initial vertical plume spread parameter (σ_{Y0}) as well as to determine the diffuse source area and release heights.

Total Width

The “total width” column of [Table 2A-3](#) provides widths of the area sources that are the maximum horizontal dimensions of the above-grade building cross-sectional areas perpendicular to the lines of sight from the building centers to the receptors. For point sources this parameter is not applicable (N/A).

σ_{Y0} and σ_{Z0}

These values are the initial lateral and vertical plume spread parameters calculated using Formulas 3 and 4 of RG 1.194.

2A.2.4 Confirmation of the ESBWR χ/Q Values

Figure 2A-1 shows the locations of the sources and receptors for ESBWR control room determinations, also used in the Fermi 3 evaluations. The dimensions of the diffuse source planes provided in Table 2A-3 are determined as directed by RG 1.194, Regulatory Position 3.2.4.5, for the nearest receptor locations. ARCON96 calculations are performed for source/receptor pairs listed in Table 2A-3 and Table 2A-4 using site-specific meteorological data. Results of the site-specific analysis are provided in Table 2.3-301 and Table 2.3-302 and Table 2.3-378 and Table 2.3-379.

2A.2.5 Confirmation of the Fuel Building and Reactor Building χ/Q Values

During movement of irradiated fuel, doors or personnel air locks on the east sides of the Reactor Building or Fuel Building could act as a point source that could result in control room χ/Q values that are higher than the ESBWR χ/Q values for a release in the Reactor Building or Fuel Building. Therefore, the doors and personnel air locks on the east sides of the Reactor Building and Fuel Building are administratively controlled to remain closed during movement of irradiated fuel.

2A.3 COL Information

2A.2-1-A Confirmation of the ESBWR χ/Q Values

This COL item is addressed in Subsection 2.3.4.3 and in Subsection 2A.2.4.

2A.2-2-A Confirmation of the Reactor Building χ/Q Values

This COL item is addressed in Subsection 2A.2.5.

2A.4 References

- 2A-1 US Nuclear Regulatory Commission, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," Regulatory Guide 1.194.
- 2A-2 US Nuclear Regulatory Commission, "Onsite Meteorological Programs," Regulatory Guide 1.23.

**Table 2A-1 ARCON96 Assumed Inputs Used for the Determination of
On-Site X/Q Values**

Parameter	Source of Input (or Reasoning)	Value
Wind Speed Units Flag (1=m/s, 2=mph, 3=knots)	RG 1.194, App. A	Varies with input
Vertical Velocity (m/s)	RG 1.194, App. A (default value/conservatism)	0
Stack Flow (m/s)	RG 1.194, App. A (default value/conservatism)	0
Stack Radius (m)	RG 1.194, App. A (default value/conservatism)	0
Wind Direction Window (degrees)	RG 1.194, App. A (default value)	90
Elevation Difference (m)	RG 1.194, App. A (All information was normalized to the finished ground level grade elevation, therefore no adjustments for elevation differences are required for ARCON96 input)	0
Surface Roughness Length (m)	RG 1.194, App. A (default value)	0.2
Minimum Wind Speed (m/s)	RG 1.194, App. A (default value)	0.5
Averaging Sector Width Constant	RG 1.194, App. A (default value)	4.3
Hours in Averages	RG 1.194, App. A (default value)	ARCON96 Default
Minimum Number of Hours	RG 1.194, App. A (default value)	ARCON96 Default

Table 2A-2 Onsite Receptor/Source Locations

Receptors	Designation
Control Building Louvers on the West face of the Control Building	CBL
Emergency Air Intakes on the East face of Control Building near the North end	EN
Emergency Air Intakes on the East face of Control Building near the South end	ES
Normal Air Intake on South face of Control Building	N
Intake for Train A of the Technical Support Center (TSC) HVAC on East face of Electrical Building near the North end	TSCA
Intake for Train B of the Technical Support Center (TSC) HVAC on North face of Electrical Building near the East end	TSCB
Sources	Designation
Reactor Building	RB
Passive Containment Cooling System (Vent on Reactor Building Roof)	PCCS
Turbine Building	TB
Turbine Building Truck Doors on the West side of the TB near the North end	TB-TD
Fuel Building	FB
Radwaste Building	RW
Reactor Building/Fuel Building Ventilation Stack	RB-VS
Turbine Building Ventilation Stack	TB-VS
Radwaste Building Ventilation Stack	RW-VS
North RB HELB blowout panel near the East edge of the Reactor Building ⁽¹⁾	BPN
South RB HELB blowout panel near the East edge of the Reactor Building ⁽¹⁾	BPS

Note:

1. There are four HELB blowout panels near the corners of the Reactor Building. ARCON96 parameters for the two blowout panels nearest to the Control Building are included in [Table 2A-3](#) as they are bounding based on the minimum distance criterion with respect to the receptors.

Table 2A-3 ARCON96 Design Inputs Used for the Determination of On-Site X/Q Values (Sheet 1 of 3)

Source/Receptor	Source Type	Distance (m)	Release Height (m)	Building Area (m ²) (2)	Intake Height (m)	Total Height (m) (3)	Total Width (m) (3)	σ_{Y0} (4)	σ_{Z0} (4)
RB to CBL	Diffuse	10	24.1	2945	2.7	48.2	49.0 ⁽¹⁾	8.17	8.03
RB to EN	Diffuse	33	24.1	2945	7.8	48.2	54.5 ⁽¹⁾	9.08	8.03
RB to ES	Diffuse	33	24.1	2945	7.8	48.2	54.5 ⁽¹⁾	9.08	8.03
RB to N	Diffuse	29	24.1	2945	7.8	48.2	59.7 ⁽¹⁾	9.95	8.03
RB to TSCB	Diffuse	131	24.1	2726	22.5	48.2	67.9 ⁽¹⁾	11.32	8.03
RB to TSCA	Diffuse	127	24.1	2726	22.5	48.2	68.5 ⁽¹⁾	11.42	8.03
PCCS to CBL	Point	38	48.2	2945	2.7	N/A	N/A	N/A	N/A
PCCS to EN	Point	54	48.2	2945	7.8	N/A	N/A	N/A	N/A
PCCS to ES	Point	63	48.2	2945	7.8	N/A	N/A	N/A	N/A
PCCS to N	Point	62	48.2	2945	7.8	N/A	N/A	N/A	N/A
PCCS to TSCB	Point	138	48.2	2726	22.5	N/A	N/A	N/A	N/A
PCCS to TSCA	Point	135	48.2	2726	22.5	N/A	N/A	N/A	N/A
TB to CBL	Diffuse	31	26.0	5513	2.7	52.0	93.2 ⁽¹⁾	15.53	8.67
TB to EN	Diffuse	29	26.0	5513	7.8	52.0	111.6 ⁽¹⁾	18.60	8.67
TB to ES	Diffuse	46	26.0	5513	7.8	52.0	108.5 ⁽¹⁾	18.08	8.67
TB to N	Diffuse	49	26.0	5513	7.8	52.0	102.9 ⁽¹⁾	17.15	8.67
TB to TSCB	Diffuse	40	26.0	3853	22.5	52.0	130.9 ⁽¹⁾	21.82	8.67

Table 2A-3 ARCON96 Design Inputs Used for the Determination of On-Site X/Q Values (Sheet 2 of 3)

Source/Receptor	Source Type	Distance (m)	Release Height (m)	Building Area (m ²) (2)	Intake Height (m)	Total Height (m) (3)	Total Width (m) (3)	σ_{Y0} (4)	σ_{Z0} (4)
TB to TSCA	Diffuse	45	26.0	3853	22.5	52.0	132.5 (1)	22.08	8.67
TB-TD to CBL	Point	156	3.8	7320	2.7	N/A	N/A	N/A	N/A
TB-TD to EN	Point	159	3.8	7320	7.8	N/A	N/A	N/A	N/A
TB-TD to TSCB	Point	97	3.8	7320	22.5	N/A	N/A	N/A	N/A
FB to CBL	Diffuse	28	11.5	2945	2.7	23.0	52.3 (1)	8.72	3.83
FB to EN	Diffuse	51	11.5	2945	7.8	23.0	49.3 (1)	8.22	3.83
FB to ES	Diffuse	40	11.5	2945	7.8	23.0	44.4 (1)	7.40	3.83
FB to N	Diffuse	34	11.5	2945	7.8	23.0	41.3 (1)	6.88	3.83
RW to N	Point	112	6.0	2945	7.8	N/A	N/A	N/A	N/A
RB-VS to CBL	Point	66	52.8	2945	2.7	N/A	N/A	N/A	N/A
RB-VS to ES	Point	86	52.8	2945	7.8	N/A	N/A	N/A	N/A
RB-VS to N	Point	81	52.8	2945	7.8	N/A	N/A	N/A	N/A
TB-VS to CBL	Point	122	71.3	5513	2.7	N/A	N/A	N/A	N/A
TB-VS to EN	Point	118	71.3	5513	7.8	N/A	N/A	N/A	N/A
TB-VS to N	Point	141	71.3	5513	7.8	N/A	N/A	N/A	N/A
RW-VS to CBL	Point	96	18.2	2945	2.7	N/A	N/A	N/A	N/A
RW-VS to EN	Point	111	18.2	2945	7.8	N/A	N/A	N/A	N/A
RW-VS to N	Point	120	18.2	2945	7.8	N/A	N/A	N/A	N/A

Table 2A-3 ARCON96 Design Inputs Used for the Determination of On-Site X/Q Values (Sheet 3 of 3)

Source/Receptor	Source Type	Distance (m)	Release Height (m)	Building Area (m ²) (2)	Intake Height (m)	Total Height (m) (3)	Total Width (m) (3)	σ_{Y0} (4)	σ_{Z0} (4)
BPN to CBL	Point	27	26.5	2945	2.7	N/A	N/A	N/A	N/A
BPN to EN	Point	40	26.5	2945	7.8	N/A	N/A	N/A	N/A
BPN to ES	Point	49	26.5	2945	7.8	N/A	N/A	N/A	N/A
BPN to N	Point	50	26.5	2945	7.8	N/A	N/A	N/A	N/A
BPS to CBL	Point	27	26.5	2945	2.7	N/A	N/A	N/A	N/A
BPS to EN	Point	49	26.5	2945	7.8	N/A	N/A	N/A	N/A
BPS to ES	Point	41	26.5	2945	7.8	N/A	N/A	N/A	N/A
BPS to N	Point	36	26.5	2945	7.8	N/A	N/A	N/A	N/A

Notes:

1. These are diffuse source widths determined in accordance with Regulatory Position 3.2.4.5 of Regulatory Guide 1.194 and are used to calculate σ_{Y0} .
2. The building vertical cross-sectional areas perpendicular to the wind for the building that has the largest impact on building wakes as described in the fifth item listed in Table A-2 of Regulatory Guide 1.194.
3. Building heights and widths are not directly used by ARCON96. They are used to calculate the lateral and vertical plume spread parameters (σ_{Y0} and σ_{Z0}).
4. Values calculated using Formulas 3 and 4 of RG 1.194.

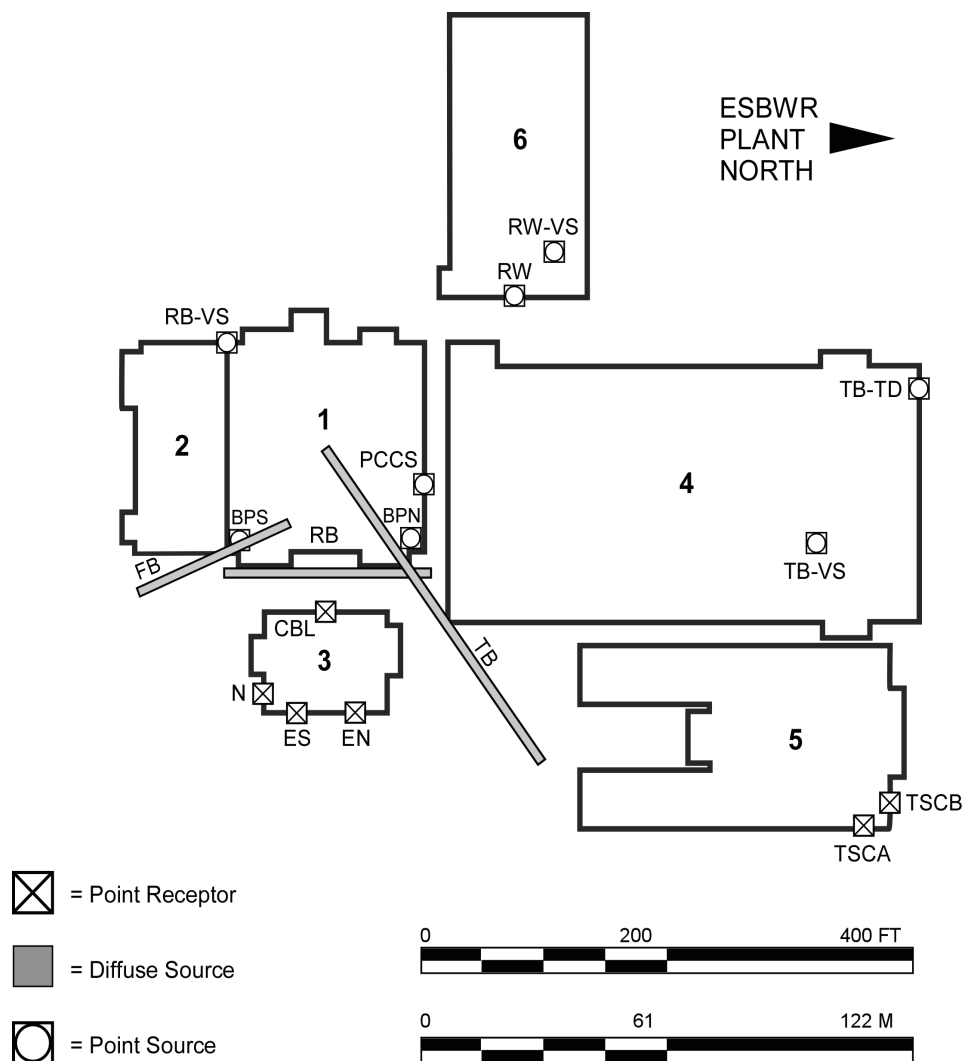
Table 2A-4 ARCON96 Input - Receptor to Source Direction (Sheet 1 of 2)

Source/Receptor	Receptor to Source Direction (degrees)
RB to CBL	289
RB to EN	279
RB to ES	299
RB to N	303
RB to TSCB	231
RB to TSCA	235
PCCS to CBL	328
PCCS to EN	304
PCCS to ES	323
PCCS to N	327
PCCS to TSCB	233
PCCS to TSCA	236
TB to CBL	2
TB to EN	343
TB to ES	350
TB to N	355
TB to TSCB	251
TB to TSCA	255
TB-TD to CBL	360
TB-TD to EN	350
TB-TD to TSCB	296
FB to CBL	247
FB to EN	253
FB to ES	267
FB to N	271

Table 2A-4 ARCON96 Input - Receptor to Source Direction (Sheet 2 of 2)

Source/Receptor	Receptor to Source Direction (degrees)
RW to N	323
RB-VS to CBL	266
RB-VS to ES	280
RB-VS to N	281
TB-VS to CBL	15
TB-VS to EN	360
TB-VS to N	7
RW-VS to CBL	321
RW-VS to EN	309
RW-VS to N	323
BPN to CBL	341
BPN to EN	304
BPN to ES	325
BPN to N	334
BPS to CBL	238
BPS to EN	248
BPS to ES	274
BPS to N	278
Fermi 3 to Fermi 2	48
Fermi 2 to Fermi 3	228

Figure 2A-1 Potential Radiological Sources and Receptors for the ESBWR Control Room



(see next page for explanation of designations used on figure)

The following designations are shown on [Figure 2A-1](#).

Plant Structures

- 1 Reactor Building
- 2 Fuel Building
- 3 Control Building
- 4 Turbine Building
- 5 Electrical Building
- 6 Radwaste Building

Control Building Receptor Locations

CBL	Control Building Louvers on the west face of the Control Building (CB)
EN	Normal and Emergency Air Intakes on the east face of CB near the north end
ES	Normal and Emergency Air Intakes on the east face of CB near the south end
N	Normal Air Intake on the south face of Control Building
TSCA	Intake for Train A of the Technical Support Center HVAC on the east face of Electrical Building near the north end
TCSB	Intake for Train B of the Technical Support Center HVAC on the north face of Electrical Building near the east end

Source Locations

RB	Reactor Building ¹
TB	Turbine Building ¹
FB	Fuel Building ¹
PCCS	Passive Containment Cooling System (Vents from the Reactor Building Roof)
RW	Radwaste Building
RB-VS	Reactor Building/Fuel Building Ventilation Stack
TB-VS	Turbine Building Ventilation Stack

1 There are 16 unique diffuse source/receptor pairs in [Table 2A-3](#) all of which cannot be represented on [Figure 2A-1](#). The planes shown in [Figure 2A-1](#) are only graphical representations of typical ESBWR diffuse source planes.

RW-VS	Radwaste Building Ventilation Stack
BPN	Blowout panel on the northeast corner of Reactor Building
BPS	Blowout panel on the southeast corner of Reactor Building
TB-TD	Turbine Building Truck Doors on the north side of the TB near the west end