Reserve Requirements Postings and LBMP Formation with Dynamic Reserves

Matthew Musto

Technical Specialist – Market Solutions Engineering

ICAPWG/MIWG

March 31, 2023

Topics Today

- Ancillary Services Prices and Requirements Postings
- LBMP sensitivity to Forecast Load Illustration
- Next Steps

Ancillary Service Prices and Requirements Postings

Current Reserve Postings – Day Ahead

- Clearing prices published by zone, hour, and product
- Requirements for each product, reserves area, and time of day variability are posted here: https://www.nyiso.com/documents/20142/3694424/Locational-Reserves-Requirements.pdf

Ancillary Services Prices, Day Ahead Market

03/16/2023

Time Stamp	Time Zone	Name	PTID	10 Min Spinning Reserve ($/MWHr)	10 Min Non-Synchronous Reserve ($/MWHr)	30 Min Operating Reserve ($/MWHr)	NYCA Regulation Capacity ($/MWHr)
00:00	EDT	CAPITL	61757	2.67	2.67	2.67	4.57
00:00	EDT	CENTRL	61754	2.67	2.67	2.67	4.57
00:00	EDT	DUNWOD	61760	2.67	2.67	2.67	4.57
00:00	EDT	GENESE	61753	2.67	2.67	2.67	4.57
00:00	EDT	HUD VL	61758	2.67	2.67	2.67	4.57
00:00	EDT	LONGIL	61762	2.67	2.67	2.67	4.57
00:00	EDT	MHK VL	61756	2.67	2.67	2.67	4.57
00:00	EDT	MILLWD	61759	2.67	2.67	2.67	4.57
00:00	EDT	N.Y.C.	61761	3.00	3.00	3.00	4.57
00:00	EDT	NORTH	61755	2.67	2.67	2.67	4.57
00:00	EDT	WEST	61752	2.67	2.67	2.67	4.57

New York ISO

Current Reserve Posting – Real-Time

- RTD clearing prices published by zone, binding five-minute interval, and product.
- RTC and RTD advisory prices are not published.
- Requirements for each product, reserves area, and time of day variability are posted here: https://www.nyiso.com/documents/20142/3694424/Locational-Reserves-Requirements.pdf

Time Stamp	Time Zone	Name	PTID	10 Min Spinning Reserve ($/MWHr)	10 Min Non-Synchronous Reserve ($/MWHr)	30 Min Operating Reserve ($/MWHr)	NYCA Regulation Capacity ($/MWHr)	NYCA Regulation Movement ($/MW)
3/16/2023 0:05	EDT	CAPITL	61757	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	CENTRL	61754	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	DUNWOD	61760	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	GENESE	61753	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	HUD VL	61758	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	LONGIL	61762	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	MHK VL	61756	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	MILLWD	61759	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	N.Y.C.	61761	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	NORTH	61755	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	WEST	61752	0	0	0	8.17	0.14

New York ISO

Proposed Postings – Day Ahead Prices

- No change to existing posting of prices.
- Continue posting clearing prices by zone, hour, and product

Ancillary Services Prices, Day Ahead Market

03/16/2023

Time Stamp	Time Zone	Name	PTID	10 Min Spinning Reserve ($/MWHr)	10 Min Non-Synchronous Reserve ($/MWHr)	30 Min Operating Reserve ($/MWHr)	NYCA Regulation Capacity ($/MWHr)
00:00	EDT	CAPITL	61757	2.67	2.67	2.67	4.57
00:00	EDT	CENTRL	61754	2.67	2.67	2.67	4.57
00:00	EDT	DUNWOD	61760	2.67	2.67	2.67	4.57
00:00	EDT	GENESE	61753	2.67	2.67	2.67	4.57
00:00	EDT	HUD VL	61758	2.67	2.67	2.67	4.57
00:00	EDT	LONGIL	61762	2.67	2.67	2.67	4.57
00:00	EDT	MHK VL	61756	2.67	2.67	2.67	4.57
00:00	EDT	MILLWD	61759	2.67	2.67	2.67	4.57
00:00	EDT	N.Y.C.	61761	3.00	3.00	3.00	4.57
00:00	EDT	NORTH	61755	2.67	2.67	2.67	4.57
00:00	EDT	WEST	61752	2.67	2.67	2.67	4.57

New York ISO

Proposed Posting of Requirements - DAM

- Formulas for each product will be posted in a document similar to how they are currently: https://www.nyiso.com/documents/20142/3694424/Locational-Reserves-Requirements.pdf
- Results of the evaluation will be posted for every interval, reserve area, and product as illustrated below:

Ancillary Services Requirements, Day Ahead Market

03/16/2023

Time Stamp	Time Zone	Name	10 Min Spinning Reserve Requirement (MW)	10 Min Non-Synchronous Reserve Requirement (MW)	30 Min Operating Reserve Requirement (MW)	Regulation Capacity Requirement (MW)
00:00	EDT	NYCA	630	1260	2520	200
00:00	EDT	EAST	500	1187	2400	0
00:00	EDT	SENY	0	0	1150	0
00:00	EDT	NYC	0	408	987	0
00:00	EDT	LONGIL	0	330	595	0

New York ISO

Proposed Posting – Real-Time Prices

- No change to existing clearing price postings.
- RTD clearing prices published by zone, binding five-minute interval, and product.

Time Stamp	Time Zone	Name	PTID	10 Min Spinning Reserve ($/MWHr)	10 Min Non-Synchronous Reserve ($/MWHr)	30 Min Operating Reserve ($/MWHr)	NYCA Regulation Capacity ($/MWHr)	NYCA Regulation Movement ($/MW)
3/16/2023 0:05	EDT	CAPITL	61757	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	CENTRL	61754	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	DUNWOD	61760	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	GENESE	61753	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	HUD VL	61758	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	LONGIL	61762	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	MHK VL	61756	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	MILLWD	61759	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	N.Y.C.	61761	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	NORTH	61755	0	0	0	8.17	0.14
3/16/2023 0:05	EDT	WEST	61752	0	0	0	8.17	0.14

Proposed Posting – RT Requirements

- Formulas for each product will be posted in a document similar to how they are currently: https://www.nyiso.com/documents/20142/3694424/Locational-Reserves-Requirements.pdf
- Results of the evaluation will be posted for the binding RTD interval, reserve area, and product as illustrated below:

Time Stamp	Time Zone	Name	PTID	10 Min Spinning Reserve Requirement (MW)	10 Min Non-Synchronous Reserve Requirement (MW)	30 Min Operating Reserve Requirement (MW)	NYCA Regulation Capacity Requirement (MW)
3/16/2023 0:05	EDT	NYCA	61757	750	1500	3000	200
3/16/2023 0:05	EDT	EAST	61754	600	1200	1650	0
3/16/2023 0:05	EDT	SENY	61760	0	0	0	0
3/16/2023 0:05	EDT	NYC	61753	0	505	700	0
3/16/2023 0:05	EDT	LONGIL	61758	0	208	490	0

New York ISO

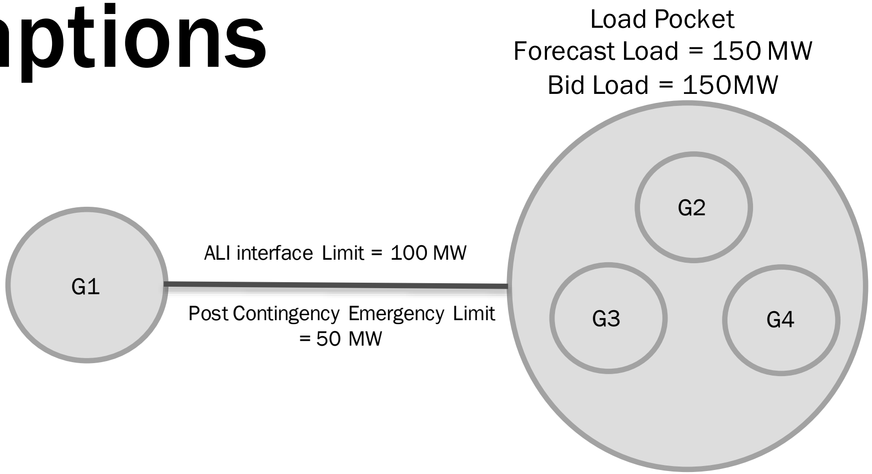
LBMP Formation with Forecast Load

DAM Examples: Introduction

- **A key benefit of Dynamic Reserves is the improved functionality to determine the least-cost generation and reserves mix to meet load, based on current system conditions.**
  - The Dynamic Reserves formulation allows the software to determine the appropriate trade-offs in a constrained area utilizing transmission headroom
  - To maintain system reliability, the Forecast Load is used to compare scheduled generation against expected flows and transmission headroom. This introduces a new factor into the LBMP calculation.

New York ISO

DAM Examples: Assumptions



- **The examples are based on a simple pipe and bubble model, with three generators (G2, G3, G4) within a load pocket and one generator (G1) outside**
  - Internal Load = 150 MW
  - All Lines In (ALI) Interface limit = 100 MW
  - Post Contingency Emergency Limit = 50 MW
- **In this example, we are calculating the reserve requirement for the load pocket.**

	UOL	Energy bid ($/MW)	Reserve bid ($/MW)
G1	100	20	N/A
G2	50	100	3
G3	50	20	5
G4	25	22	3

New York ISO

Optimal Solution

- The least-cost solution results in the following reserve requirement for the load pocket:

	UOL	Energy bid ($/MW)	Reserve bid ($/MW)	Energy Schedule (MW)	Reserve Schedule (MW)
G1	100	20	N/A	75	-
G2	50	100	3	0	25
G3	50	20	5	50	0
G4	25	22	3	25	0

- Headroom = Limit – Flow = Limit – (Forecast Load – Generation in the Load pocket) = 100 – (150 – 75) = 25 MW
- Reserve requirement (RR) = Max(RR for Loss of Transmission, RR for Loss of Generation) = 25 MW
  - RR for Loss of Transmission = Flow - Post Contingency Emergency Limit = (150-75) - 50 = 25 MW
  - RR for Loss of Generation = G3 Energy – Headroom = 50 – 25 = 25 MW
- Production cost = Energy Cost + Reserve cost = $20*75 + $20*50 + $22*25 + $3*25= $3125

- The March 7, 2023 ICAPWG/MIWG went into further detail on why this is the most optimal solution.

New York ISO

LBMP Calculation

- LBMP is defined as the change in production cost for serving the next MW of Bid load.
- In this example the optimal solution results in a production cost of $3,125
- We need to determine what the optimal solution is if BID Load were to increase from 150MW to 151MW in the Load Pocket and what the resulting production cost would be.
- The difference between the 151MW Bid Load production cost and the 150MW Bid Load production cost is the LBMP.

New York ISO

151MW Optimal Solution

- The least-cost solution results in the following reserve requirement for the load pocket:

	UOL	Energy bid ($/MW)	Reserve bid ($/MW)	Energy Schedule (MW)	Reserve Schedule (MW)
G1	100	20	N/A	76	-
G2	50	100	3	0	25
G3	50	20	5	50	0
G4	25	22	3	25	0

  - Headroom = Limit – Flow = Limit – (Forecast Load – Generation in the Load pocket) = 100 – (150 – 75) = 25 MW
  - Reserve requirement (RR) = Max(RR for Loss of Transmission, RR for Loss of Generation) = 25 MW
    - RR for Loss of Transmission = Flow - Post Contingency Emergency Limit = Forecast Load – LP Generation – Limit = (150-75) - 50 = 25 MW
    - RR for Loss of Generation = G3 Energy – Headroom = 50 – 25 = 25 MW
  - Production cost = Energy Cost + Reserve cost = $20*76 + $20*50 + $22*25 + $3*25= $3145
- The change in production cost and thus LBMP is: $3,145-$3,125 = $20
- $20 does not cover the marginal cost of G4 which is meeting the load with a 25MW schedule

New York ISO

Discussion on LBMP

- In this example, the resources inside the load pocket appear more attractive because they avoid having to procure reserves. For example, G4 energy would appear to cost $19 instead of its bid $22 because every MW of energy avoids a $3 reserve MW from G2.
- The relationship between increasing Bid load served and the Reserve Requirement is not always captured in the LBMP because Forecast Load and headroom do not necessarily change.
  - Thus, the existing LBMP definition may not allow -marginal (or near marginal) resources to recover their incremental costs
- Potential factors that affect this are if Forecast Load is greater than Bid Load and if the headroom is constrained.
- NYISO is developing a proposal to accurately account for Dynamic Reserve constraints in the LBMP.
  - This effort could result in the need to revise the definition of LBMP which would require large software development and testing efforts

New York ISO

Next Steps

- Return to MIWG with LBMP formation proposal
- Return to MIWG with settlements examples

New York ISO

Questions?

Appendix I: Mathematical Formulation

New York ISO

Securing Reserve Area for the Loss of Generation

- **The first concept is that reserves should cover for the largest source contingency in a Reserve Area, less available headroom**
  - Available headroom would reflect the ability to import reserves into the existing reserve region
  - Currently, largest source contingency in a Reserve Area is determined by the largest single generation schedule
- **In addition to the largest single-source contingency, NYISO is proposing additional constraints to be considered when evaluating the largest source contingency:**
  - Correlated loss of multiple generators: Multiple resources that share a single point of failure (transmission tower, gas regulator valve)
  - Intermittent resource contingencies: Resources in close geographic proximity that may be susceptible to a common weather pattern, which poses a risk of simultaneous loss or reduction of energy output
- **An example of the generic formulation for Loss of Generation (applied to a 30-Minute Reserve product) is:**

$$Res_{\mathrm{RA}_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k} \in \mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{30Total}\}\} - RA_{a_{Headroom}}$$

New York ISO

Securing Reserve Area for the Loss of Transmission

- **The second concept is that reserves should account for the loss of transmission (energy imports) into an existing reserve area**
  - This evaluation calculates the difference between the post-contingency interface limits and the current flow, following the loss of the largest line on the interface
  - Loss of Transmission is not considered when evaluating NYCA reserve requirements because external proxies are evaluated as generators
- **An example of the generic formulation for Loss of Transmission (applied to a 30-Minute Reserve product in a locality) is:**

$$30minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

New York ISO

Tying Loss of Generation and Loss of Transmission Together

- The equations for the generation and transmission constraints would be co-optimized along with energy, reserves, and transmission
- The reserve requirements would be determined by the most restrictive equation for each reserve product in each reserve area
  - Would be dynamically determined in DAM and RTM

Equations: Securing a Reserve Area for the Loss of Generation

Calculating Actual Energy Flows in a Reserve Area

$$RA_{a_{Flow_i}} = (RA_{a_{Load_i}} + RA_{a_{Losses_i}} - RA_{a_{Gen_i}})$$

- $\mathrm{RA_a}$ is the applicable reserve area
- $\mathrm{RA_{a_{Flow_i}}}$ is the actual energy flow into or out of reserve area *a* for time step *i*
  - $RA_{a_{Flow_i}}$ is positive into reserve area *a*
  - $RA_{a_{Flow_i}}$ is negative out of reserve area *a*
  - Note: For the NYCA reserve area (Load Zones A-K), $RA_{a_{Flow_i}}$ value is equal to 0 MW because external proxies are evaluated as generators
- $\mathrm{RA_{a_{Load_i}}}$ is the forecasted load in reserve area *a* for time step *i* (Day-Ahead or Real-Time, as applicable)
- $RA_{a_{Losses_i}}$ is the calculated losses in reserve area a for time step *i* (Day-Ahead or Real-Time, as applicable)
- $\mathrm{RA_{a_{Gen_i}}}$ is the sum of all energy schedules on resources inside reserve area *a* for time step *i*

Calculating the Available Transmission Headroom in a Reserve Area for Generation

$$RA_{a_{Headroom}} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

- $\mathrm{RA}_{Headroom}$ is the capability to secure reserves external to reserve area *a* for time step *i*
- $\mathrm{RA}_{\mathrm{a}_{\mathrm{EmerLimit}_\mathrm{i}}}$ is the pre-contingency emergency limit for the reserve area *a* for time step *i*
  - Note: For the NYCA reserve area (Load Zones A-K), the $RA_{EmerLimit}$ and $RA_{NormLimit}$ value is equal to 0 MW because external proxies are evaluated as generators

New York ISO

Multipliers Determine Product Quality Ratios

$$Res_{RA_{a_i}}^{10Spin} \geq Mult_{\mathrm{RA}_a}^{10Spin} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{10SPin}\}\} - RA_{a_{Headroom}}$$

$$Res_{RA_{a_i}}^{10Total} \geq Mult_{\mathrm{RA}_a}^{10Total} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{10Total}\}\} - RA_{a_{Headroom}}$$

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k}\in\mathrm{Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{30Total}\}\} - RA_{a_{Headroom}}$$

- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{\mathrm{10Spin}}$ is the $10 -$ minute spinning reserve requirement in reserve area a for time step i
- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{\mathrm{10Total}}$ is the $10 -$ minute total reserve requirement in reserve area a for time step i
- $\mathrm{Res}_{\mathrm{RA}_{a_i}}^{\mathrm{30Total}}$ is the $30 -$ minute total reserve requirement in reserve area a for time step i

Securing a Reserve Area for the Loss of Transmission

Contingency Headroom on Interface

$$10minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

$$30minute_{PostCon_{Import_{RA_{a_i}}}} = Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}$$

- $\mathrm{10minute}_{\mathrm{PostCon}_{\mathrm{Import}_{\mathrm{RA}_{\mathrm{a}_\mathrm{i}}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 10 minutes
- $\mathrm{30minute}_{\mathrm{PostCon}_{\mathrm{Import}_{\mathrm{RA}_{\mathrm{a}_\mathrm{i}}}}}$ is the applicable post-contingency transfer limit of reserve area *a* for time step *i* that the flow should be under within 30 minutes
- $\mathrm{Limit}_{N-1\mathrm{Emer}_{\mathrm{RA}_{\mathrm{a}_\mathrm{i}}}}$ is the emergency transfer limit of reserve area *a* for time step *i*, with the largest in-service element taken out of service
- $\mathrm{Limit}_{\mathrm{N}-2\mathrm{Emer}_{\mathrm{RA}_{\mathrm{a}_\mathrm{i}}}}$ is the emergency transfer limit of reserve area *a* for time step *i*, with the two largest in-service element taken out of service

Contingency Headroom on Interface

- The difference between the applicable transfer limit and the flow is the available import capability
  - When negative, this number represents a deficiency that needs to be held as reserves within the reserve area due to the lack of transmission headroom to import reserves.
- All limits will be calculated via an offline study by NYISO Operations

New York ISO

Securing the RA for Loss of Transmission

$$Res_{RA_{a_i}}^{10Spin} \geq -Mult_{\mathrm{RA}_a}^{10Spin} * (10minute_{PostCon_{Import_{RA_{a_i}}}})$$

$$Res_{RA_{a_i}}^{10Total} \geq -(10minute_{PostCon_{Import_{RA_{a_i}}}})$$

$$Res_{RA_{a_i}}^{30Total} \geq -(30minute_{PostCon_{Import_{RA_{a_i}}}})$$

The multiplier is only used for Spin as it represents a quality flag (percentage) of the 10T requirement which should be held as spinning. Any number from 0 to 1 is valid.

Tying the Loss of Generation and Loss of Transmission Together

Securing for one source contingency and N-1 transmission contingency

- $Res_{RA_{a_i}}^{30Total} \geq \{\max_{k \in \mathrm{Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - (Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}})$

New York ISO

Simultaneous Constraints 30-Minute Total Reserves

- **Secure multiple of largest generator to emergency transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k\in Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{30Total}\}\} - RA_{a_{Headroom}}$$

$$RA_{a_{Headroom}} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

- **Secure transmission for N-2 to emergency transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq -(Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}})$$

- **Secure for loss of two elements within 30 minutes:**

$$Res_{RA_{a_i}}^{30Total} \geq \{\max_{\mathrm{k\in Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - (Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}})$$

The more restrictive of the equations will determine the applicable requirement for the reserve area.

New York ISO

Simultaneous Constraints 30-Minute Total Reserves

- **Secure multiple of largest generator to emergency transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq Mult_{\mathrm{RA}_a}^{30Total} * \{\max_{\mathrm{k \in Gen}_{RA_a}} \{gen_{k_i} + res_{k_i}^{30Total}\}\} - RA_{a_{Headroom}} + ORDC + RA_{scarcity_i}$$

$$RA_{a_{Headroom}} = RA_{a_{EmerLimit_i}} - RA_{a_{Flow_i}}$$

- **Secure transmission for N-2 to emergency transfer capability:**

$$Res_{RA_{a_i}}^{30Total} \geq -\left(Limit_{N-2Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}\right) + ORDC + RA_{scarcity_i}$$

- **Secure for loss of two elements within 30 minutes:**

$$Res_{RA_{a_i}}^{30Total} \geq \{\max_{\mathrm{k \in Gen}_{RA_a}} \{\mathrm{gen}_{k_i} + res_{k_i}^{30Total}\}\} - (Limit_{N-1Emer_{RA_{a_i}}} - RA_{Flow_{a_i}}) + ORDC + RA_{scarcity_i}$$

- **Scarcity Minimum Reserve Constraint Penalty Cost**

$$Res_{RA_{a_i}}^{30Total} \geq RA_{scarcity_i} + \$500\_Penalty\_Cost\_Curve$$

The more restrictive of the equations will determine the applicable requirement for the reserve area.