# Operating Procedures

ISO New England Operating Procedure No. 14

*Technical Requirements for Generators,Demand Resources and Asset Related Demands – Appendix B – Generator Reactive Data Explanation of Terms and Instructions for Data Preparation for ISO Form NX-12D*

Effective Date: April 5, 2007
Revision No. 4

# APPENDIX B -GENERATOR REACTIVE DATA EXPLANATION OF TERMS AND INSTRUCTIONS FOR DATA PREPARATION FOR ISO FORM NX-12D

## GENERAL INFORMATION

The NX-12D Generator Reactive Data form requests entry of ***gross*** Generator reactive output (MVAR) based on both the manufacturers' nameplate capability and on the Generator normal operating capability. The Generator nameplate lagging and leading MVAR output capability is based on the design parameters of the Generator field winding, end turn winding and stator. This capability represents the theoretical maximum reactive capability of a specific Generator.

The Generator nameplate operating lagging and leading MVAR output capability ***can be*** limited by any one of several devices or considerations other than Generator field winding, end turn winding or stator design. Limiting devices can be equipment such as excitation limiters, electrical and/or thermal protection relaying, etc. Limiting considerations can be station voltage requirements, auxiliary equipment constraints, GSU and/or transmission restrictions, contractual arrangements, etc. In all of these cases, the Generator ***can not operate*** at the manufactures' nameplate reactive capability. This restricted capability represents the normal reactive operating capability. Having both sets of reactive data, nameplate and normal, will allow identification of Generators where potential upgrades may be justified to enhance system reliability.

The reactive data is required for:

- All fossil Generators having a real power output in excess of 10 MW
- All nuclear Generators regardless of real power output
- All hydro Generators having a real power output in excess of 10 MW. This includes data for Generators capable of operation as synchronous condensers and/or as Dispatchable Asset Related Demands
- For compensation purposes (under Schedule 2) all Generators have to submit an NX-12D

Data is required for each Generator comprising a defined Generator that meets these data submittal guidelines. For two or more identical Generators comprising a defined Generator, one NX-12D may be submitted; however, clearly indicate whether the data is for each individual Generator or for the combination of Generators.

Data is required where a Generator's normal reactive operating capability is substantially affected by infrequent abnormal system conditions, (i.e., line-out conditions, a Generator outage at a defined Generator, seasonal fuel type conversion, etc.) that are not specifically covered by existing guides, procedures or criteria, a second complete set of data highlighting the limitations should be provided.

Once an initial NX-12D has been provided, any change in a defined Generator's MVAR capability or voltage schedule should be reported through normal Generator - Local Control Center - ISO New England channels to insure reliable system operation. If it is determined that the change will be either long term in nature (˜1 year) or of a permanent nature, a revised NX-12D Attachment highlighting the change should be submitted.

## SPECIFIC INFORMATION

***Documentation of Data Preparation*** - The first time an NX-12D is filed, it will be assigned Data Revision Number 0. Each time revised data is submitted, the Data Revision number will be incremented. The effective date is to be at least five (5) work days following the receipt of the data by the designated recipient at ISO New England.

***Reactive Capability*** - The ability of a Generator to supply gross lagging and/or leading MVAR capability to the transmission network.

MVAR Output Level - The gross reactive power output of a Generator over a range of different gross real power (MW) output levels.

MW Output Level - The gross real power output levels corresponding to reported MVAR data. This relationship is demonstrated in the sample figures provided below.

Maximum MVAR Lagging - The maximum amount of lagging reactive power that can be delivered to the system (overexcited state), as measured at the Generator's leads for various levels of real power output. Generator lagging capability is expressed in terms of field design limitations at the lower Generator MW outputs and stator design limitations at the higher MW outputs. In Figure 1 below, point #4 represents the transition between the two lagging curve sections based on field verses stator limits respectively.

Maximum MVAR Leading - The maximum amount of leading reactive power that can be delivered to the system (underexcited state), as measured at the Generator's leads for particular levels of real power output. Generator leading capability is expressed in terms of end turn winding design limitations at the lower Generator MW outputs and stator design limitations at the higher MW outputs.

**Figure 1 - Typical Capability Curve for a Turbine Generator at Various Hydrogen Pressures**

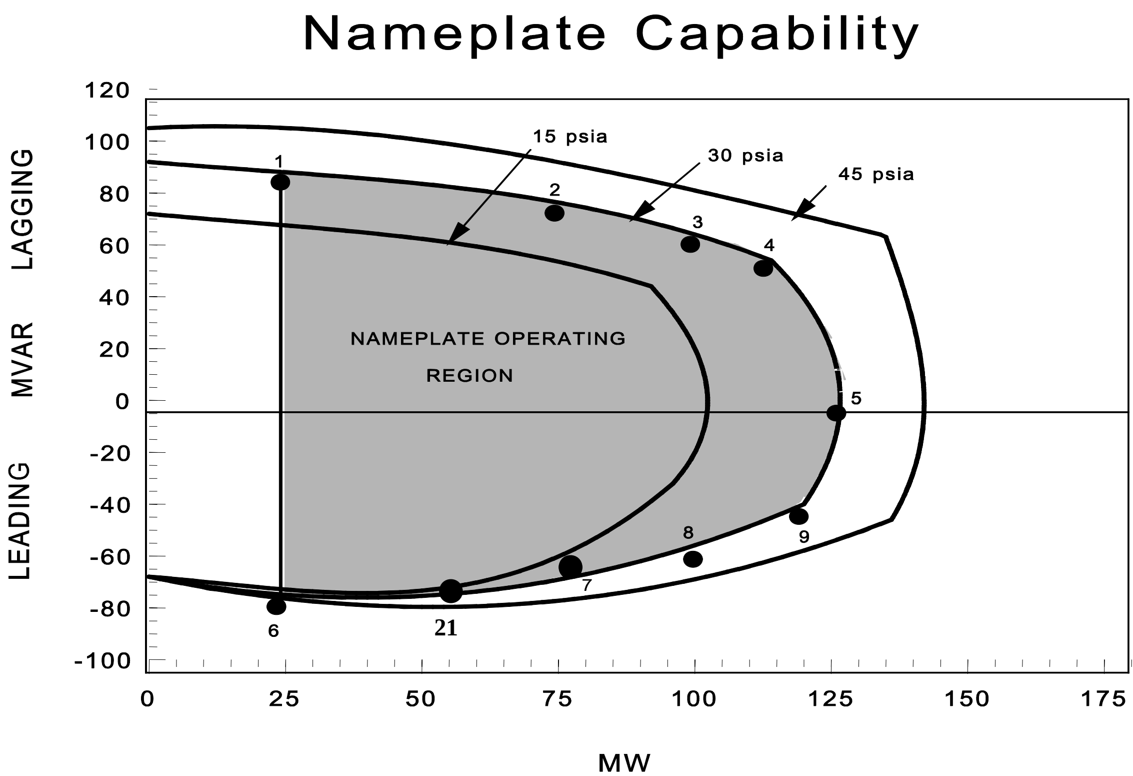


Figure #1 demonstrates typical nameplate capability curves for a sample Generator at various hydrogen pressures when not encumbered by any protective or limiting concerns. The sample Generator is designed to operate at 30 psia Hydrogen pressure level.

For Generator nameplate capability, the case where the Generator reactive capability is design limited, the requested data consists of nine points (#1 through #9) along the capability curve (see figure #1).

- Point #1 is the maximum MVAR lagging capability at minimum manual Generator MW output (use the lower of the winter or summer minimum manual MW output capability).
- Point #2 is the maximum MVAR lagging capability at the intermediate MW output. Intermediate MW output is defined as the mid-point between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability), and the minimum manual MW output value used for Point #1.
- Point #3 is the maximum MVAR lagging capability at the three quarter MW output. Three quarter MW output is defined as 75% between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability), and the minimum manual MW output value used for Point #1.
- Point #4 is the maximum MVAR lagging capability at the reactive curve break point (point of transition between the two lagging curve sections based on field winding verses stator design limits).
- Point #5 is the maximum MW capability of the Generator at unity MPF, (no lagging or leading capability).
- Point #6 is the maximum MVAR leading capability at minimum manual Generator MW output (this is the same MW output used for Point #1).

- Point #7 is the maximum MVAR leading capability at the intermediate MW output. Intermediate MW output is defined as the mid-point between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability). This is the same MW output used for Point #2.

- Point #8 is the maximum MVAR leading capability at the three quarter MW output. Three quarter MW output is defined as 75% between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability). This is the same MW output used for Point #3.

- Point #9 is the maximum MVAR leading capability at the reactive curve break point (point of transition between the two lagging curve sections based on end turn winding verses stator design limits). Points #9 and #4, the two break points, do not necessarily correspond to the same MW output of the Generator.

- Point #21 is the most restrictive maximum MVAR leading capability attainable at the EcoMin MW output. Figure #1 shows a relative point where this capability may occur, but is dependent on Generator EcoMin offers.

**Figure 2 - Typical Capability Curve for a Turbine Generator at Rated Hydrogen Pressure**

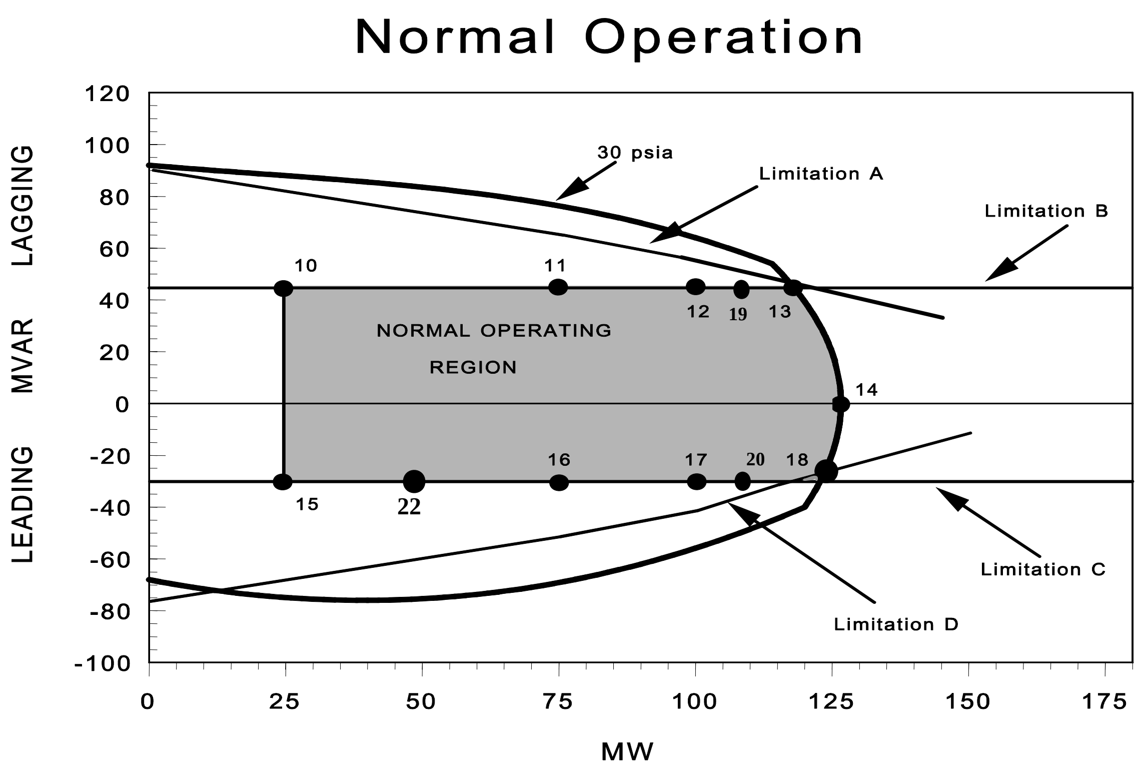


Figure #2 shows the same Generator nameplate capability curve when the nameplate lagging and/or leading capability is limited by any one of several devices or considerations other than Generator field or stator design limits. In this case, Generator can not operate at some or all of the design nameplate capability indicated in Figure #1. The sample Generator is designed to operate at 30 psia Hydrogen pressure.

These capability curves represent MW and MVAR output levels as measured at the Generator leads (prior to station service). For the purposes of data reporting, gross MW and MVAR output levels should be reported. To facilitate data submittal, Generator capability curves should be attached to the NX-12D form.

For the Generator normal operating capability, the case where the Generator reactive capability is limited by devices or considerations other than design parameters, the Generator's output can be derived from the detailed capability curve similar to the sample shown in Figure 2. The requested data consists of nine points (points #10 through #18) along the capability curve. For each of these points, the actual lagging and leading capability is less than that indicated by the corresponding points 1 through 9 on the sample Generator capability curve shown in figure #1. Figure #2 shows the effect on the actual Generator curve when it is restricted by example limitations A through D. If the Generator was not limited at any of the corresponding MW output values by these limitations, then by default, the normal operating capability would be the same as the manufactures nameplate capability and no additional reactive data would be required.

- Point #10 is the most restrictive maximum MVAR lagging capability attainable at minimum manual Generator MW output (the same corresponding MW output as in point #1, Figure #1).

- Point #11 is the most restrictive maximum MVAR lagging capability attainable at intermediate MW output (the same corresponding MW output as in point #2, Figure #1).

- Point #12 is the most restrictive maximum MVAR lagging capability attainable at three quarter MW output (the same corresponding MW output as in point #3, Figure #1).

- Point #13 is the most restrictive maximum MVAR lagging capability attainable where the limitation is the point where the limiting concern of the B constraint line intersects the Generator capability curve. This is not technically a break point in the true sense of the definition but merely the intersection of two limitations. Point #13 and point #4, Figure #1; do not necessarily correspond to the same MW output of the Generator.

- Point #14 is the maximum MW capability of the Generator at unity MPF, (no lagging or leading capability). Generally this point would be the same as point #5, Figure #1. An example of where point #14 and point #5 would differ is the case where a generating unit is operated at a lower hydrogen pressure that it was designed for.

- Point #15 is the most restrictive maximum MVAR leading capability attainable at minimum manual generating unit MW output (the same corresponding MW output as in point #6, Figure #1).

- Point #16 is the most restrictive maximum MVAR leading capability attainable at intermediate MW output (the same corresponding MW output as in point #7, Figure #1).

- Point #17 is the most restrictive maximum MVAR leading capability attainable at three quarter MW output (the same corresponding MW output as in point #8, Figure #1).

- Point #18 is the most restrictive maximum MVAR leading capability attainable where the limitation is the point the constraint line of limiting concern B intersects the Generator capability curve. This is not technically a break point in the true sense of the definition but merely the intersection of two limitations. Point #18 and point #9, Figure #1, do not necessarily correspond to the same MW output of the Generator.

- Point #19 is the most restrictive maximum MVAR lagging capability attainable at Summer Seasonal Claimed Capability MW output.

- Point #20 is the most restrictive maximum MVAR leading capability attainable at Summer Seasonal Claimed Capability MW output.

- Point #22 is the most restrictive maximum MVAR leading capability attainable at the EcoMin MW output. Figure #2 shows a relative point where this capability may occur, but is dependent on Generator EcoMin offers.

Maximum MVAR leading and lagging while motoring (HYDRO GENERATOR S ONLY) - Motoring is the term given to a Hydro Generator that can operate as a synchronous condenser and therefore are operating at a zero MW output. In this case please provide the maximum leading and lagging MVAR capability of the Generator while motoring.

Maximum MVAR leading and lagging while pumping (DISPATCHABLE ASSET RELATED DEMANDS ONLY) - Pumping is the term given to a Dispatchable Asset Related Demand that can operate as a motor used to pump water back in to the reservoir. In this case please provide the maximum leading and lagging MVAR capability of the Dispatchable Asset Related Demands in the full pump mode.

Nature of Limitation - Provide information regarding the difference between the nameplate and normal operating reactive capabilities, i.e. identification of limiting equipment, contractual arrangements, operational requirements, etc..

Station Service Load - Provide the larger of the two gross MW and MVAR station service loads for operation at either the summer or winter full load capability (maximum MW output).

***Generator Interconnection Impedance*** - There are several data entry options based on the definition of the bulk transmission system, (all transmission 69 kV and above).

*For Generators Directly Connected to The Bulk Transmission* - Data for the Generator step-up transformer (GSU) impedance and tap capability should be provided on an NX-9B Data Form found in OP-16. If the NX-9B has not been filed, that information must be provided in this section of the NX-12D.

*For Generators Not Directly Connected to The Bulk Transmission* - Data for the equivalent impedance from Generator terminals to the nearest bulk transmission substation must be provided. If the Generator has a GSU, the GSU impedance should be modeled separately from the equivalent transmission impedance.

When a Generator is connected to the system via equivalent impedance, it is possible there may be intermediate busses between the Generator and the bulk transmission system that are not explicitly modeled. These busses may have load and/or shunt that could reduce the contribution of the Generator as seen by the bulk transmission system. To accurately capture this effect, a composite of the loads and shunts that are not modeled in detail should be represented on the Generator bus.

***Generator Voltage Schedule*** - Generator voltage schedule information must be provided for all Generators. If a Generator is directly connected to the bulk transmission system, (69 kV and above) or is connected to the bulk transmission system via an equivalent impedance that includes a series GSU, then a highside regulated bus voltage schedule and a minimum to maximum acceptable highside voltage range is required. When the Generator is controlling highside voltage across a transformer, there may also be a voltage constraint on the low voltage Generator terminals; therefore, a minimum to maximum acceptable voltage operating range at the Generator terminals is also required.

If a Generator is connected to the bulk transmission system via an equivalent impedance that does not have an imbedded GSU, then only provide a terminal bus voltage schedule and a minimum to maximum acceptable terminal voltage range.

In the case of a Dispatchable Asset Related Demand that can operate in the pumping mode, similar voltage scheduling information as that provided for generation mode should be provided for pumping mode.

Any minimum to maximum acceptable voltage range should accurately reflect restrictions on Generator operation, i.e., terminal voltage constraints, auxiliary equipment limitations, station service requirements, GSU and transmission restrictions and/or contractual arrangements, etc.

| Theoretical Values | Nameplate Reactive Capability | | | | Normal Operating Reactive Capability (2*) | | | | Station Service Load (1*) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Lagging* | | *Leading* | | *Lagging* | | *Leading* | | | |
| **MW Output Reference** | MW | MVAR | MW | MVAR | MW | MVAR | MW | MVAR | MW | MVAR |
| **Minimum Manual Load Point (3*)** | | | | | | | | | | |
| **Intermediate Load Point (4*)** | | | | | | | | | | |
| **Three Quarter Load Point (5*)** | | | | | | | | | | |
| **Break Point Load (6*)** | | | | | | | | | | |
| **Transitional Load Point (7*)** | | | | | | | | | | |
| **Unity Generating Unit Power Factor Load Point (9*)** | | | | | | | | | | |
| **Motoring Capability** | | | | | | | | | | |
| **Full Pumping Capability** | | | | | | | | | | |

| Theoretical and Tested Values | Nameplate Reactive Capability | | Normal Operating Reactive Capability | | Tested Reactive Capability | | Station Service | | Date Tested |
|---|---|---|---|---|---|---|---|---|---|
| **MW Output Reference** | MW | MVAR | MW | MVAR | MW | MVAR | MW | MVAR | mm/dd/yyyy |
| **At S-SCC Load Point - Lag Test (*8)** | | | | | | | | | |
| **At EcoMin Load Point - Lead Test (10*)** | | | | | | | | | |

**For further explanation please see notes within OP-14 Appendix B*

**Notes:**

## 3.Generator Interconnection Impedance

| Impedance values reflect those between the generating unit GSU highside terminal through the network to the interconnecting bulk transmission bus (11*) *All Values Supplied should be in Percent on a 100 MVA Base* | | |
|---|---|---|
| **Resistance R** | **Reactance X** | **Susceptance B** |
| | | |
| **GSU Parameters in Percent on a 100 MVA Base** | | |
| **Resistance R** | **Reactance X** | **Tap Position in Per Unit** |
| | | |
| **Bus Loading Not Explicitly Modeled on Equivalent Network (12*)** | | |
| **MW** | **MVAR** | **Shunt Admittance** |
| | | |

## 4. Generator Voltage Schedules

| Heavy Load Season Regulated Bus Voltages in kV (13*) | | Light Load Season Regulated Bus Voltages in kV (13*) | |
|---|---|---|---|
| **Summer and Winter** | | **Spring and Fall** | |
| **Highside Scheduled Voltage** | **Min/Max Acceptable Voltage Range(14*)** | **Highside Scheduled Voltage** | **Min/Max Acceptable Voltage Range(14*)** |
| | | | |
| **Terminal Bus Voltages in kV** | | **Terminal Bus Voltages in kV** | |
| | | | |

## 5.Generating unit capability curve.

*Please attach a .jpg image from the generating unit capability D curve*

**(1*)** The station service load reported should be the higher of the two station service loads from either the winter or summer full load operation.

**(2*)** Provide only if reactive capability is limited by any one of several limiting devices or considerations to levels less than the manufactures nameplate. This data form assumes a Generator can operate between its listed maximum lagging capability and zero MVAR. If for some reason, a Generator must maintain a minimum lagging MVAR output and cannot operate down to zero output, please indicate in the space provided below.

**(3*)** For the Minimum Manual Load Point, use the lower of the winter or summer generating unit minimum manual MW output capability.

**(4*)** For the Intermediate Load Point, use the mid-point between the maximum MW output of the Generator at unity MPF, (no lagging or leading capability), and the minimum manual MW output value defined in note #3.

**(5*)** For the Three Quarter Load Point, use the three quarter point between the maximum MW output of the Generator at unity MPF, (no lagging or leading capability), and the minimum manual MW output value defined in note #3.

**(6*)** Nameplate points #4 and #9 do not necessarily correspond to the same value of real power output of the Generator. Specification of the lagging MW and leading MW level of operation may be required.

**(7*)** Normal Operating points #13 and #18 do not necessarily correspond to the same value of real power output of the Generator. Specification of the lagging MW and leading MW level of operation may be required.

**(8*)** Normal Operating Points # 19 and # 20 represent the most restricted Normal Operating Reactive Capability of the Generator corresponding to the Seasonal Summer Clamed Capability.

**(9*)** It is possible to have two valid MW entries for the unity MPF point (points #5 and #14). Example: Nameplate operation of the Generator is at 30 psia Hydrogen and the Normal operation of the generating unit is at 15 psia Hydrogen. In this case there are two x axis cross over points. Please provide both the Nameplate and Normal MW values in the space provided for in the table.

(**10***) Normal Operating Points # 21 and # 22 represent the most restricted Normal Operating Reactive Capability of the generating unit corresponding to the EcoMin value.

**(11*)** If there is a generating unit step-up transformer, include its impedance separate from the equivalent transmission impedance. Also include the GSU tap position. If a GSU is not present or an NX-9B Data Form within OP-16 has been filed, the middle row of this table need not be completed.

**(12*)** When a generating unit is connected via an equivalent transmission impedance, there is the potential to eliminate modeling of intermediate busses which may contain load and/or shunt. A composite of these values should be modeled on the generating unit bus to accurately capture the net generating unit contribution to the network.

**(13*)** Generating unit voltage schedule information must be provided for all generating units. If a generating unit is directly connected to the bulk transmission system, (69 kV and above) or is connected to the bulk transmission system via an equivalent impedance that includes a series GSU, (see section 2), then a highside regulated bus voltage schedule and a minimum to maximum acceptable highside voltage range is required. When the generating unit is controlling voltage across a transformer, there may also be a voltage constraint on the low voltage generating unit terminals, therefore, a minimum to maximum acceptable generating unit terminal voltage range is also required.

If a generating unit is connected to the bulk transmission system via an equivalent impedance and does not have a series GSU, then only provide a generating unit terminal bus voltage schedule and a minimum to maximum acceptable terminal voltage range.

**(14*)** The minimum to maximum acceptable voltage ranges should accurately reflect restrictions on generating unit operation, i.e., terminal voltage constraints, auxiliary equipment limitations, station service requirements, GSU and transmission restrictions and/or contractual arrangements, etc.

## OP 14 Appendix B Revision History

**Document History** (This Document History documents action taken on the equivalent NEPOOL Procedure prior to the RTO Operations Date as well revisions made to the ISO New England Procedure subsequent to the RTO Operations Date.)

| Rev. No. | Date | Reason |
|---|---|---|
| Rev 1 | 10/23/98 | |
| Rev 2 | 05/28/04 | |
| Rev 3 | 02/01/05 | Updated to conform to RTO Terminology |
| Rev 4 | 04/05/07 | Revised for Schedule 2 VAR process changes and annual review |