Nasdaq Calypso

ISDA SIMM and Schedule Methodology and Analytics

Version 18

Revision 1.0
February 2024
Approved

Document History

Revision	Published	Summary of Changes
1.0	February 2024	First revision for version 18

This document covers the implementation of all regulatory formulas and other requirements provided by ISDA regulation in Calypso UMR solution.

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Overview

This document describes the calculations and methodology for calculating the Initial Margin under the ISDA Standard Initial Margin (SIMM) and SCHEDULE models for non-cleared OTC derivatives under Uncleared Margin Rules (UMR).

Initial Margin is calculated per margin account (CSA), where trades are subject to 2 groups of regulations: **Post_Regulations** and **Collect_Regulations**. IM of "Collect_Regulations" is calculated on the **Receive** side, by considering risk factors as it is, including values and signs. IM of "Post_Regulations" is calculated on the **Pay** side, by considering risk factors with same values but different signs. If regulations vary between the "Post_Regulations" and "Collect_Regulations", Initial Margin is calculated under each regulation, the worst case will be retained as the value for Pay and Receive margins, one worst case on the Pay side, and one worst case on the Receive side. Each margin account has same or different margin currencies on Receive and Pay sides, and IMs are calculated firstly using all risk factor in amount USD and then converted to margin currency.

Please refer to the Calypso Bilateral Margin User Guide for details.

Here is the list of regulations for Post_Regulations and Collect_Regulations.

Regulation	Region	Long Name
AMFQ	Quebec, Canada	Autorité des Marchés Financiers
APRA	Australia	Australian Prudential Regulation Authority
BACEN	Brazil	Banco Central do Brasil
BANX	Mexico	Banco de Mexico
CFTC	USA	Commodity Futures Trading Commission
ESA	EU	European Supervisory Authorities
FINMA	Switzerland	Financial Market Supervisory Authority
HKMA	Hong Kong	Hong Kong Monetary Authority
JFSA	Japan	Japanese Financial Services Agency
KFSC	South Korea	Korean Financial Services Commission
MAS	Singapore	Monetary Authority of Singapore
OSFI	Canada	Office of the Superintendent of Financial Institutions
RBI	India	Reserve Bank of India
SANT	South Africa	South African National Treasury

Regulation	Region	Long Name
SEC	USA	Securities Exchange Commission (segregated)
SEC-unseg	USA	Securities Exchange Commission (unsegregated)
SFC	Hong Kong	Securities and Futures Commission
UK	United Kingdom	United Kingdom Regulators
USPR	USA	US Prudential Regulators

The standardized approach of total initial margin per account is

$$Total\ IM = SIMM\ IM + SCHEDULE\ IM + Additional\ IM$$

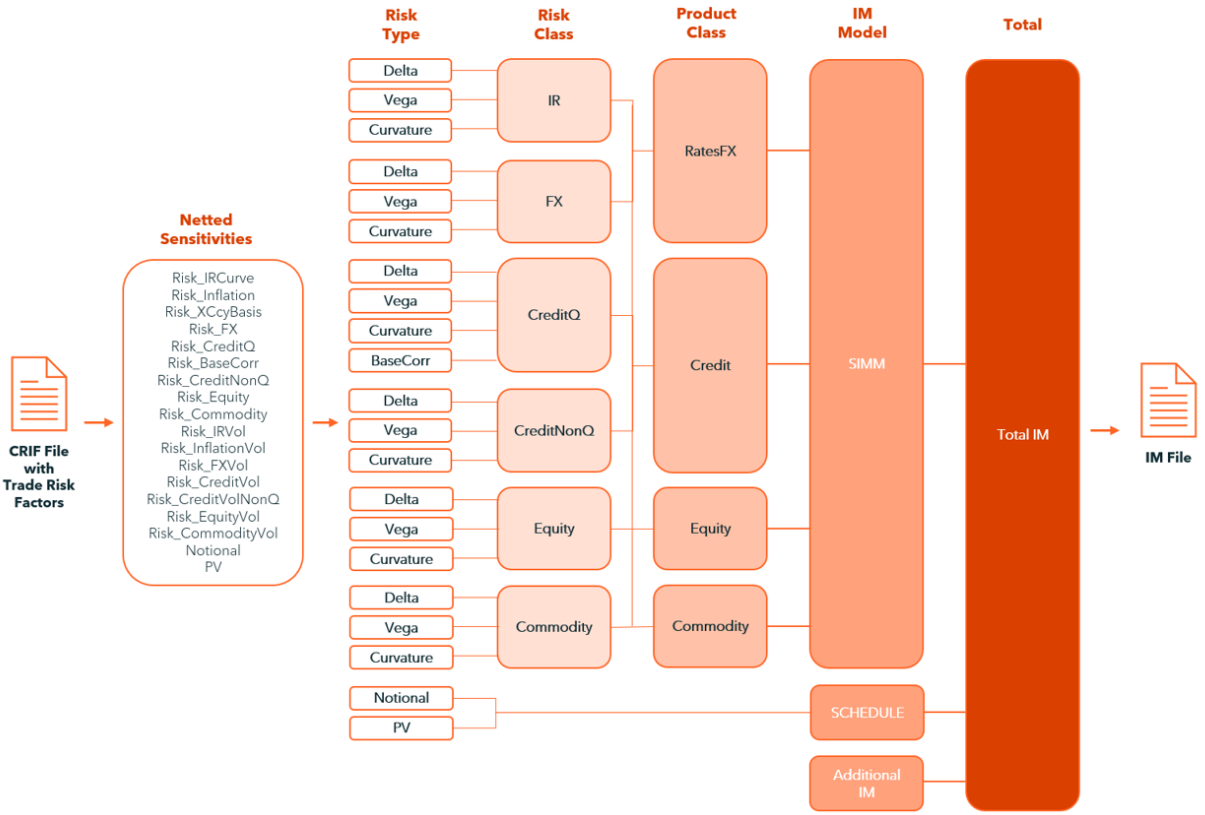
Total IM is calculated at margin account level under each regulator from pay and receive side. Whether a trade should be covered under SIMM IM model or SCHEDULE IM Model is decided by trade product type, as well as margin account and regulator definition. In Calypso, this is defined using Param_ScheduleProduct and Param_LocalRegSIMM parameters. Each product type is covered in one IM model under one regulator, and SIMM IM is calculated for all product types belong to SIMM model, and SCHEDULE IM is calculated for all product types belong to SCHEDULE model.

The detailed calculation of above three components (SIMM IM, SCHEDULE IM and Additional IM) is described in the following sections.

User must run scheduled task MARGIN_CALCULATOR to get IM results, and the prerequisites of IM calculation are:

- Reference data setup including margin account, margin group and regulators, via UI or MARGIN_INPUT scheduled task.
- Risk factors imported from CRIF file or calculated from trades, via UI or MARGIN_INPUT scheduled task. Import mode supports all risk factors. Calculate mode supports risk factors including Risk_IRCurve, Risk_Inflation, Risk_XCcyBasis, Risk_IRVol, Risk_InflationVol, Risk_FX, Risk_FXVol, Risk_CreditQ, Risk_Equity, Risk_EquityVol, Risk_Commodity, Risk_CommodityVol, Notional, and PV.
- ISDA static data.

Please refer to the Calypso Bilateral Margin User Guide for details for reference data and ISDA version setup, product types supported in calculating mode as well as details of MARGIN_INPUT and MARGIN_CALCULATOR scheduled tasks.


Risk Type
Risk Class
Product Class
IM Model
Total
CRIF File with Trade Risk Factors
Netted Sensitivities
Risk_IRCurve
Risk_Inflation
Risk_XCcyBasis
Risk_FX
Risk_CreditQ
Risk_BaseCorr
Risk_CreditNonQ
Risk_Equity
Risk_Commodity
Risk_IRVol
Risk_InflationVol
Risk_FXVol
Risk_CreditVol
Risk_CreditVolNonQ
Risk_EquityVol
Risk_CommodityVol
Notional
PV
Delta
Vega
Curvature
IR
FX
BaseCorr
CreditQ
CreditNonQ
Equity
Commodity
RatesFX
Credit
SIMM
SCHEDULE
Additional IM
Total IM
IM File

SIMM Methodology

2.1 SIMM IM Computation

The IM calculation of SIMM model is phased by following steps.

- Calculate Margin by risk class.
- Calculate Margin by product class (by factoring in risk class IM components).
- Calculate SIMM IM (by summing up product class IM).

Margin by Risk Class

There are six risk classes:

- Interest Rate (IR)
- Credit Qualifying (CreditQ)
- Credit Non-Qualifying (CreditNonQ)
- Equity
- Commodity
- FX

Margin for each risk class is the sum of the Delta Margin, the Vega Margin, the Curvature Margin, and the Base Corr Margin (if applicable).

$$IM_x = DeltaMargin_x + VegaMargin_x + CurvatureMargin_x + BaseCorrMargin_x$$

where x represents each risk class, and BaseCorrMargin is only applicable for Credit Qualifying risk class.

Note that curvature margin is calculated based on Curvature risk factors, which is derived from Vega risk factors. This is handled during IM calculation process and users do not need to have curvature risk factors provided in CRIF file.

The detailed calculation of Delta Margin, Vega Margin, Curvature Margin, and Base Corr Margin are explained in section Margin by Risk Class.

Margin by Product Class

There are four product classes:

- Interest Rate and FX (RatesFX)
- Credit
- Equity
- Commodity

SIMM calculation is considered separately for each product class, and each trade is assigned to one of product class. For example, equity derivatives belong to Equity product class, and they would have risk in interest rate and equity

risk classes. Within each product class, the initial margin (IM) for each risk class is calculated as in Margin by Risk Class.

The total margin for that product class is given by the formula:

$$SIMM_{product} = \sqrt{\sum_{r} IM_r{}^2 + \sum_{r}\sum_{r\neq s} \psi_{rs} IM_r IM_s}$$

where $product$ is one of the four product classes. IM_r and IM_s are calculated over the six risk classes. ψ_{rs} is correlation between risk class r and risk class s.

Correlation matrix ψ_{rs} cross different risk classes based on ISDA version 2.6 (effective in Dec 2023) is given as:

	Interest Rate	Credit Qualifying	Credit Non-Qualifying	Equity	Commodity	FX
Interest Rate	100%	4%	4%	7%	37%	14%
Credit Qualifying	4%	100%	54%	70%	27%	37%
Credit Non-Qualifying	4%	54%	100%	46%	24%	15%
Equity	7%	70%	46%	100%	35%	39%
Commodity	37%	27%	24%	35%	100%	35%
FX	14%	37%	15%	39%	35%	100%

For example, $SIMM_{credit}$ in below case is calculated from IM of six risk classes based on correlation matrix ψ_{rs}.

		IM for six risk classes					
Product Class	**RISK_IM**	**RISK_FXIM**	**RISK_IRIM**	**RISK_CRIM**	**RISK_CRNQIM**	**RISK_EQIM**	**RISK_COMMODITYIM**
RatesFX	60372045795	58357483868	9321026274				
Credit	6305975760	601384810.3	5183381677	416684611.6	2814967775	15000000	34000000
Equity	22772698197					22772698197	
Commodity	58733120787						58733120787

IM risk class		IM_r	IM_s	correlation	Production
RISK_FXIM	RISK_FXIM	601384810.3	601384810.3	100%	3.61664E+17
RISK_FXIM	RISK_IRIM	601384810.3	5183381677	14%	4.36409E+17
RISK_FXIM	RISK_CRIM	601384810.3	416684611.6	37%	9.27175E+16
RISK_FXIM	RISK_CRNQIM	601384810.3	2814967775	15%	2.53932E+17
RISK_FXIM	RISK_EQIM	601384810.3	15000000	39%	3.5181E+15
RISK_FXIM	RISK_COMMODITYIM	601384810.3	34000000	35%	7.15648E+15
RISK_IRIM	RISK_FXIM	5183381677	601384810.3	14%	4.36409E+17
RISK_IRIM	RISK_IRIM	5183381677	5183381677	100%	2.68674E+19
RISK_IRIM	RISK_CRIM	5183381677	416684611.6	4%	8.63934E+16
RISK_IRIM	RISK_CRNQIM	5183381677	2814967775	4%	5.83642E+17
RISK_IRIM	RISK_EQIM	5183381677	15000000	7%	5.44255E+15
RISK_IRIM	RISK_COMMODITYIM	5183381677	34000000	37%	6.52069E+16
RISK_CRIM	RISK_FXIM	416684611.6	601384810.3	37%	9.27175E+16
RISK_CRIM	RISK_IRIM	416684611.6	5183381677	4%	8.63934E+16
RISK_CRIM	RISK_CRIM	416684611.6	416684611.6	100%	1.73626E+17
RISK_CRIM	RISK_CRNQIM	416684611.6	2814967775	54%	6.33395E+17
RISK_CRIM	RISK_EQIM	416684611.6	15000000	70%	4.37519E+15
RISK_CRIM	RISK_COMMODITYIM	416684611.6	34000000	27%	3.82516E+15
RISK_CRNQIM	RISK_FXIM	2814967775	601384810.3	15%	2.53932E+17
RISK_CRNQIM	RISK_IRIM	2814967775	5183381677	4%	5.83642E+17
RISK_CRNQIM	RISK_CRIM	2814967775	416684611.6	54%	6.33395E+17
RISK_CRNQIM	RISK_CRNQIM	2814967775	2814967775	100%	7.92404E+18
RISK_CRNQIM	RISK_EQIM	2814967775	15000000	46%	1.94233E+16
RISK_CRNQIM	RISK_COMMODITYIM	2814967775	34000000	24%	2.29701E+16
RISK_EQIM	RISK_FXIM	15000000	601384810.3	39%	3.5181E+15
RISK_EQIM	RISK_IRIM	15000000	5183381677	7%	5.44255E+15
RISK_EQIM	RISK_CRIM	15000000	416684611.6	70%	4.37519E+15
RISK_EQIM	RISK_CRNQIM	15000000	2814967775	46%	1.94233E+16
RISK_EQIM	RISK_EQIM	15000000	15000000	100%	2.25E+14
RISK_EQIM	RISK_COMMODITYIM	15000000	34000000	35%	1.785E+14
RISK_COMMODITYIN	RISK_FXIM	34000000	601384810.3	35%	7.15648E+15
RISK_COMMODITYIN	RISK_IRIM	34000000	5183381677	37%	6.52069E+16
RISK_COMMODITYIN	RISK_CRIM	34000000	416684611.6	27%	3.82516E+15
RISK_COMMODITYIN	RISK_CRNQIM	34000000	2814967775	24%	2.29701E+16
RISK_COMMODITYIN	RISK_EQIM	34000000	15000000	35%	1.785E+14
RISK_COMMODITYIN	RISK_COMMODITYIM	34000000	34000000	100%	1.156E+15
				SUM	3.97653E+19
				IM Credit	6305975760

SIMM IM

The total SIMM is the sum of SIMM of four product classes.

$$SIMM = SIMM_{RatesFX} + SIMM_{Credit} + SIMM_{Equity} + SIMM_{Commodity}$$

2.2 Margin by Risk Class

2.2.1 Delta Margin

2.2.1.1 Interest Rate Class

Delta margin for interest rate risk class is calculated based on risk types Risk_IRCurve, Risk_Inflation and Risk_XCcyBasis.

IR Delta Margin Step by Step Formula

The following is step by step approach of delta margin calculation for interest rate class.

a) Calculate **aggregated sensitivities** $S_{k,i}$ with same risk type, qualifier, bucket, label1 and label2 for each product class and margin account.

b) For each currency (qualifier) and risk type, calculate **concentration risk factor** CR_b based on their threshold levels and **weighted sensitivities** based on weights for different currency bucket and tenor. They are defined as:

$$WS_{k,i} = RW_k S_{k,i} CR_b$$

$$CR_b = \max\left(1, \left(\frac{|\sum_{k,i} s_{k,i}|}{T_b}\right)^{\frac{1}{2}}\right)$$

where k is the rate tenor (such as 1y) and i is the sub yield curve (such as Libor3M), and RW_k is the corresponding weight for the currency and tenor. T_b is the concentration threshold defined for each currency.

Note that inflation sensitivities should be included in $\sum_{k,i} s_{k,i}$ while calculating CR_b. Cross-currency basis swap sensitivities should not be included in in $\sum_{k,i} s_{k,i}$ while calculating CR_b.

c) Calculate K , which is the weighted sensitivities being aggregated within each currency.

$$K = \sqrt{\sum_{i,k} WS_{k,i}^2 + \sum_{i,k} \sum_{(j,l)\neq(i,k)} \phi_{i,j} \rho_{k,l} WS_{k,i} WS_{i,j}}$$

where $\phi_{i,j}$ is sub-curve correlation and $\rho_{k,l}$ is the tenor correlation.

d) Calculate Delta Margin, which should be aggregated across currencies within same product class.

$$DeltaMargin = \sqrt{\sum_b K_b^2 + \sum_b \sum_{b\neq c} \gamma_{bc} g_{bc} S_b S_c}$$

where

$$S_b = max\left(min\left(\sum_{i,k} WS_{k,i}, K_b\right), -K_b\right)$$

and

$$g_{bc} = \frac{min(CR_b, CR_c)}{max(CR_b, CR_c)}$$

γ_{bc} is the correlation between currency b and c.

IR Delta Margin Static Data

Below is the static data used to calculate interest rate delta margin, based on ISDA version 2.6 (effective in Dec 2023).

Interest Rate Delta – Risk Weights

The delta risk weights for interest rate risk are given by currency groups and tenors. This is used in above Step b).

Regular-volatility currencies: USD, EUR, GBP, CHF, AUD, NZD, CAD, SEK, NOK, DKK, HKD, KRW, SGD, TWD.

Low-volatility currencies: JPY.

High-volatility currencies: all other currencies.

	2w	1m	3m	6m	1y	2y	3y	5y	10y	15y	20y	30y
Regular-Vol Ccy	109	105	90	71	66	66	64	60	60	61	61	67
Low-Vol Ccy	15	18	9	11	13	15	19	23	23	22	22	23
High-Vol Ccy	163	109	87	89	102	96	101	97	97	102	106	101

The risk weight for any currency's inflation rate is 61.

The risk weight for any currency's cross-currency basis swap spread is 21.

Interest Rate Delta - Concentration Thresholds

The delta concentration thresholds for interest rate risk (inclusive of inflation risk) are given by currency groups. This is used in above Step b).

Currency Group	Currencies	Concentration Threshold (USD mm/bp)
High Volatility	All other currencies	30
Regular Volatility, well-traded	USD, EUR, GBP	330

Currency Group	Currencies	Concentration Threshold (USD mm/bp)
Regular Volatility, less well-traded	AUD, CAD, CHF, DKK, HKD, KRW, NOK, NZD, SEK, SGD, TWD	130
Low Volatility	JPY	61

Interest Rate Delta – Correlation

The delta correlation cross tenors $\rho_{k,l}$ are given as below. This is used in above Step c).

	2w	1m	3m	6m	1y	2y	3y	5y	10y	15y	20y	30y
2w	100%	77%	67%	59%	48%	39%	34%	30%	25%	23%	21%	20%
1m	77%	100%	84%	74%	56%	43%	36%	31%	26%	21%	19%	19%
3m	67%	84%	100%	88%	69%	55%	47%	40%	34%	27%	25%	25%
6m	59%	74%	88%	100%	86%	73%	65%	57%	49%	40%	38%	37%
1y	48%	56%	69%	86%	100%	94%	87%	79%	68%	60%	57%	55%
2y	39%	43%	55%	73%	94%	100%	96%	91%	80%	74%	70%	69%
3y	34%	36%	47%	65%	87%	96%	100%	97%	88%	81%	77%	76%
5y	30%	31%	40%	57%	79%	91%	97%	100%	95%	90%	86%	85%
10y	25%	26%	34%	49%	68%	80%	88%	95%	100%	97%	94%	94%
15y	23%	21%	27%	40%	60%	74%	81%	90%	97%	100%	98%	97%
20y	21%	19%	25%	38%	57%	70%	77%	86%	94%	98%	100%	99%
30y	20%	19%	25%	37%	55%	69%	76%	85%	94%	97%	99%	100%

The correlation between sub-curves $\phi_{i,j}$ of the same currency is 99.3%.

The correlation between inflation rate and any yield for the same currency is 24%.

The correlation between cross-currency basis swap spread and any yield or inflation rate for the same currency is 4%.

The correlation between currencies γ_{bc} is 32%.

IR Delta Margin Examples

Interest Rate Delta

Here is an example of interest rate delta margin calculation following IR Delta Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

ProductClass	Sensitivity_Id	CollectRegulations	RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
RatesFX	S_IR_3	All	Risk_IRCurve	USD	1	1y	Municipal	2,000,000	USD	2,000,000
RatesFX	S_IR_21	All	Risk_IRCurve	JPY	2	3m	Libor3m	1,500,000	USD	1,500,000
RatesFX	S_IR_37	All	Risk_IRCurve	MXN	3	1y	Libor6m	9,000,000	USD	9,000,000
RatesFX	S_IR_38	All	Risk_IRCurve	MXN	3	2y	Libor12m	10,000,000	USD	10,000,000
RatesFX	S_IR_37	All	Risk_IRCurve	MXN	3	1y	Libor6m	9,000,000	USD	9,000,000
RatesFX	S_IR_38	All	Risk_IRCurve	MXN	3	2y	Libor12m	10,000,000	USD	10,000,000

Aggregate same sensitivities with same criteria

ProductClass	Sensitivity_Id	CollectRegulations	RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
RatesFX	S_IR_3	All	Risk_IRCurve	USD	1	1y	Municipal	2,000,000	USD	2,000,000
RatesFX	S_IR_21	All	Risk_IRCurve	JPY	2	3m	Libor3m	1,500,000	USD	1,500,000
RatesFX	S_IR_37	All	Risk_IRCurve	MXN	3	1y	Libor6m	18,000,000	USD	18,000,000
RatesFX	S_IR_38	All	Risk_IRCurve	MXN	3	2y	Libor12m	20,000,000	USD	=SUM(K19,K21)

SUM(number1, [number2],

b) Calculate **concentration risk factor** and **weighted sensitivities.**

D10 =MAX(1,SQRT(ABS(D9)/D8))

	A	B	C	D
6	Concentration Risk	RatesFX		
7	Currency	USD	JPY	MXN
8	Threshold	330000000	61,000,000	30000000
9	Sum of Sk (exclude Xccy)	2,000,000	1,500,000	38,000,000
10	CR	1	1	1.125462868

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	Index-Tenor	Weight	Weight*Sk*CR
Risk_IRCurve	USD	1	1y	Municipal	2,000,000	USD	2,000,000	Municipal-1y	66	=K26*M26*B10
Risk_IRCurve	JPY	2	3m	Libor3m	1,500,000	USD	1,500,000	Libor3m-3m	9	13500000
Risk_IRCurve	MXN	3	1y	Libor6m	18,000,000	USD	18,000,000	Libor6m-1y	102	2066349825
Risk_IRCurve	MXN	3	2y	Libor12m	20,000,000	USD	20,000,000	Libor12m-2y	96	2160888706

c) Calculate K for each currency.

Aggregate the weighted sensitivities within each currency, using a sub-curve correlation at the curve/tenor level (Calculation of K factor)

ProductClass	Currency	Index-Tenor Sk	Index-Tenor Sl	Wsk	Wsl	Correlation	SubCurve	Production
RatesFX	USD	Municipal-1y	Municipal-1y	132,000,000	132,000,000	100%	100%	1.7424E+16
							K-USD	132000000

ProductClass	Currency	Index-Tenor Sk	Index-Tenor Sl	Wsk	Wsl	Correlation	SubCurve	Production
RatesFX	JPY	Libor3m-3m	Libor3m-3m	13,500,000	13,500,000	100%	100%	1.8225E+14
							K-JPY	13500000

ProductClass	Currency	Index-Tenor Sk	Index-Tenor Sl	Wsk	Wsl	Correlation	SubCurve	Production
RatesFX	MXN	Libor6m-1y	Libor6m-1y	2,066,349,825	2,066,349,825	100%	100%	4.2698E+18
RatesFX	MXN	Libor6m-1y	Libor12m-2y	2,066,349,825	2,160,888,706	94%	99%	=E49*F49*G49*H49
RatesFX	MXN	Libor12m-2y	Libor6m-1y	2,160,888,706	2,066,349,825	94%	99%	4.16786E+18
RatesFX	MXN	Libor12m-2y	Libor12m-2y	2,160,888,706	2,160,888,706	100%	100%	4.66944E+18
							K-MXN	4156316393

d) Calculate S for each currency and Delta Margin.

Calculation of Sb factor

ProductClass	Currency	k	k^2	Sum of WSk	Sb
RatesFX	USD	132000000	1.7424E+16	132000000	132000000
RatesFX	JPY	13500000	1.8225E+14	13500000	13500000
RatesFX	MXN	4156316393	1.7275E+19	4227238531	4156316393

RatesFX		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
USD	USD	132000000	132000000	1	1	100%	100%	0
USD	JPY	132000000	13500000	1	1	32%	100%	5.7024E+14
USD	MXN	132000000	4156316393	1	1.125462868	32%	89%	1.55992E+17
JPY	USD	13500000	132000000	1	1	32%	100%	5.7024E+14
JPY	JPY	13500000	13500000	1	1	100%	100%	0
JPY	MXN	13500000	4156316393	1	1.125462868	32%	89%	1.59537E+16
MXN	USD	4156316393	132000000	1.125462868	1	32%	89%	1.55992E+17
MXN	JPY	4156316393	13500000	1.125462868	1	32%	89%	1.59537E+16
MXN	MXN	4156316393	4156316393	1.125462868	1.125462868	100%	100%	0
							SUM	3.45031E+17
							SUM of K^2	1.72926E+19
							Delta Margin	4199714676

Interest Rate delta margin in IM output file can be found in column Risk_IRCURVE.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_IRCURVE	RISK_IRCURVATURE	RISK_IRVOL	RISK_IRIM
ISDA-C66	USD	4.2E+09	Receive	All	RatesFX	4199714676	4199714676			4199714676
ISDA-C66	USD	4.2E+09	Receive	All	Credit	0				
ISDA-C66	USD	4.2E+09	Receive	All	Equity	0				
ISDA-C66	USD	4.2E+09	Receive	All	Commodi	0				

2.2.1.2 Non-Interest Rate Classes

Delta margin for **FX** is calculated based on risk type Risk_FX.

Delta margin for **Credit Qualifying** is calculated based on risk type Risk_CreditQ.

Delta margin for **Credit Non-Qualifying** is calculated based on risk type Risk_CreditNonQ.

Delta margin for **Equity** is calculated based on risk type Risk_Equity.

Delta margin for **Commodity** is calculated based on risk type Risk_Commodity.

Non-IR Delta Margin Step by Step Formula

The following is step by step approach of delta margin calculation for non-interest rate classes.

a) Calculate **aggregated sensitivities** S_k with same risk type, qualifier, bucket, label1 and label2 for each product class and margin account.
b) Calculate **concentration risk factor** CR_b and **weighted sensitivities** RW_k according to the bucketing structure for each risk class. More details are provided in Non-IR Delta Margin Static Data.

$$WS_k = RW_k S_k CR_k$$

For credit spread risk

$$CR_k = \max\left(1, \left(\frac{|\sum_j s_j|}{T_b}\right)^{\frac{1}{2}}\right)$$

where the sum of j taken over all the risk factors that have the same issuer and seniority as the risk factor k, irrespective of the tenor or payment currency.

For Equity, Commodity and FX risk,

$$CR_k = \max\left(1, \left(\frac{|s_k|}{T_b}\right)^{\frac{1}{2}}\right)$$

where T_b is the concentration threshold for bucket (or FX category) b.

Note that base correlation sensitivities are not included in concentration risk, and concentration risk of Risk_BaseCorr is 1.

c) Calculate K , which is the weighted sensitivities being aggregated within each bucket.

$$K = \sqrt{\sum_k WS_k^2 + \sum_k \sum_{l \neq k} \rho_{kl} f_{kl} WS_k WS_l}$$

where

$$f_{kl} = \frac{min(CR_k, CR_l)}{max(CR_k, CR_l)}$$

$\rho_{k,l}$ is the bucket correlation.

d) Calculate Delta Margin, which should be aggregated across buckets within same product class.

$$DeltaMargin = \sqrt{\sum_b K_b^2 + \sum_b \sum_{b \neq c} \gamma_{bc} S_b S_c} + K_{residual}$$

where

$$S_b = max\left(min\left(\sum_{i,k} WS_{k,i}, K_b\right), -K_b\right)$$

γ_{bc} is the bucket correlation.

Non-IR Delta Margin Static Data

Below is the static data used to calculate FX, Credit Qualifying, Credit Non-Qualifying, Equity and Commodity delta margin, based on ISDA version 2.6 (effective in Dec 2023).

FX Delta - Risk Weights

The delta risk weights for FX risk depend on the group of the calculation currency, as well as the group of currency concerned. This is used in above Step b).

High FX volatility currencies: BRL, RUB, TRY.

Regular FX volatility currencies: all other currencies.

FX Volatility Group	Regular (calculation ccy)	High (calculation ccy)
Regular (given ccy)	7.4	14.7
High (given ccy)	14.7	21.4

FX Delta – Concentration Thresholds

The delta concentration thresholds for FX risk are given by currency groups. This is used in above Step b).

FX Risk Group	Currencies	Concentration Threshold (USD mm/bp)
Category 1 – Significantly material	USD, EUR, JPY, GBP, AUD, CHF, CAD	3300
Category 2 – Frequently traded	BRL, CNY, HKD, INR, KRW, MXN, NOK, NZD, RUB, SEK, SGD, TRY, ZAR	880
Category 3 – Others	All other currencies	170

FX Delta – Correlation

The correlation ρ_{kl} of FX risk depends on the group of the calculation currency, as well as the group of currency concerned. This is used in above Step c).

When calculation currency is in the **regular** FX volatility group:

FX Volatility Group	Regular	High
Regular	50%	25%
High	25%	-5%

When calculation currency is in the **high** FX volatility group:

FX Volatility Group	Regular	High
Regular	88%	72%
High	72%	50%

Credit Qualifying Delta – Risk Weights

The delta risk weights for Credit Qualifying risk depend on buckets based on issuer/seniority. The same risk weight should be used for all vertices (1y, 2y, 3y, 5y, 10y) according to bucket. This is used in above Step b).

Bucket Number	Credit Quality	Sector	Risk Weights
1	Investment Grade (IG)	Sovereigns including central banks	75
2		Financials including government-backed financials	90
3		Basic materials, energy, industrials	84
4		Consumer	54
5		Technology, telecommunications	62
6		Health care, utilities, local government, government-backed corporates (non-financial)	48
7	High Yield (HY) & non-rated (NR)	Sovereigns including central banks	185
8		Financials including government-backed financials	343
9		Basic materials, energy, industrials	255
10		Consumer	250
11		Technology, telecommunications	214
12		Health care, utilities, local government, government-backed corporates (non-financial)	173
Residual			343

Credit Qualifying Delta – Concentration Thresholds

The delta concentration thresholds of Credit Qualifying risk depend on credit risk group and bucket. This is used in above Step b).

Bucket(s)	Credit Risk Group	Concentration Threshold (USD mm/bp)
1,7	Sovereigns including central banks	1.0

Bucket(s)	Credit Risk Group	Concentration Threshold (USD mm/bp)
2-6, 8-12	Corporate entities	0.17
Residual	Not classified	0.17

Credit Qualifying Delta – Correlation

The correlation ρ_{kl} of Credit Qualifying risk within the same bucket is defined in the following table. This is used in above Step c).

	Same issuer/seniority, Different vertex or currency	Different issuer/seniority
Aggregate sensitivities	93%	46%
Residual Bucket	50%	50%

The correlation ρ_{kl} applying to Base Correlation risks across different index families is 29%

The correlation γ_{bc} applying to different non-residual bucket is defined in the following table.

Bucket	1	2	3	4	5	6	7	8	9	10	11	12
1	100%	38%	38%	35%	37%	34%	42%	32%	34%	33%	34%	33%
2	38%	100%	48%	46%	48%	46%	39%	40%	41%	41%	**43%**	40%
3	38%	48%	100%	50%	51%	50%	40%	39%	45%	44%	47%	42%
4	35%	46%	50%	100%	50%	50%	37%	37%	41%	43%	45%	40%
5	37%	48%	51%	50%	100%	50%	39%	38%	43%	43%	46%	42%
6	34%	46%	50%	50%	50%	100%	37%	35%	39%	41%	44%	41%
7	42%	39%	40%	37%	39%	37%	100%	33%	37%	37%	35%	35%
8	32%	40%	39%	37%	38%	35%	33%	100%	36%	37%	37%	36%
9	34%	41%	45%	41%	43%	39%	37%	36%	100%	41%	40%	38%
10	33%	41%	44%	43%	43%	41%	37%	37%	41%	100%	41%	39%
11	34%	43%	47%	45%	46%	44%	35%	37%	40%	41%	100%	40%

Bucket	1	2	3	4	5	6	7	8	9	10	11	12
12	33%	40%	42%	40%	42%	41%	35%	36%	38%	39%	40%	100%

Credit Non-Qualifying Delta – Risk Weights

The delta risk weights for Credit Non-Qualifying risk depend on buckets. This is used in above Step b).

Bucket Number	Credit Quality	Sector	Risk Weights
1	Investment Grade (IG)	RMBS/CMBS	280
2	High Yield (HY) & non-rated (NR)	RMBS/CMBS	1300
Residual			1300

Credit Non-Qualifying Delta – Concentration Thresholds

The delta concentration thresholds of Credit Non-Qualifying risk depend on credit risk group and bucket. This is used in above Step b).

Bucket	Credit Risk Group	Concentration Threshold (USD mm/bp)
1	IG (RMBS and CMBS)	9.5
2	HY/Non-rated (RMBS and CMBS)	0.50
Residual	Not classified	0.50

Credit Non-Qualifying Delta – Correlation

The correlation ρ_{kl} of Credit Non-Qualifying risk within the same bucket is defined in the following table. This is used in above Step c).

	Same group name (Such as CMBX, ABX)	Different group
Aggregate sensitivities	93%	46%
Residual Bucket	50%	50%

The correlation γ_{bc} applying to different non-residual bucket is 43%.

Equity Delta – Risk Weights

The delta risk weights for Equity risk depend on buckets. This is used in above Step b).

Bucket	Size	Region	Sector	Risk Weight
1	Large	Emerging Markets	Consumer goods and services, transportation and storage, administrative and support service activities, healthcare, utilities	30
2			Telecommunications, industrials	33
3			Basic materials, energy, agriculture, manufacturing, mining and quarrying	36
4			Financials including gov't-backed financials, real estate activities, technology	29
5		Developed Markets	Consumer goods and services, transportation and storage, administrative and support service activities, healthcare, utilities	26
6			Telecommunications, industrials	25
7			Basic materials, energy, agriculture, manufacturing, mining and quarrying	34
8			Financials including gov't-backed financials, real estate activities, technology	28
9	Small	Emerging Markets	All sectors	36
10		Developed Markets	All sectors	50
11	All	All	Indexes, Funds, ETFs	19
12	All	All	Volatility Indexes	19
Residual				50

Equity Delta – Concentration Thresholds

The delta concentration thresholds of Equity risk depend on bucket. This is used in above Step b).

Bucket(s)	Equity Risk Group	Concentration Threshold (USD mm/%)
1-4	Emerging Markets – Large Cap	3
5-8	Developed Markets – Large Cap	12
9	Emerging Markets – Small Cap	0.64
10	Developed Markets – Small Cap	0.37
11-12	Indexes, Funds, ETFs, Volatility Indexes	810
Residual	Not classified	0.37

Equity Delta – Correlation

The correlation ρ_{kl} of Equity risk within the same bucket is defined in the following table. This is used in above Step c).

Bucket Number	Correlation
1	18%
2	20%
3	28%
4	24%
5	25%
6	36%
7	35%
8	37%
9	23%
10	27%
11	45%
12	45%
Residual	0%

The correlation γ_{bc} applying to different non-residual bucket is defined in the following table.

Bucket	1	2	3	4	5	6	7	8	9	10	11	12
1	100%	18%	19%	19%	14%	16%	15%	16%	18%	12%	19%	19%
2	18%	100%	22%	21%	15%	18%	17%	19%	20%	14%	**21%**	21%
3	19%	22%	100%	22%	13%	16%	8%	17%	22%	13%	20%	20%
4	19%	21%	22%	100%	17%	22%	22%	23%	22%	17%	26%	26%
5	14%	15%	13%	17%	100%	29%	26%	29%	14%	24%	32%	32%
6	16%	18%	16%	22%	29%	100%	34%	36%	17%	30%	39%	39%
7	15%	17%	8%	22%	26%	34%	100%	33%	16%	28%	36%	36%
8	16%	19%	17%	23%	29%	36%	33%	100%	17%	29%	40%	40%
9	18%	20%	22%	22%	14%	17%	16%	17%	100%	13%	21%	21%
10	12%	14%	13%	17%	24%	30%	28%	29%	13%	100%	30%	30%
11	19%	**21%**	20%	26%	32%	39%	36%	40%	21%	30%	100%	45%
12	19%	21%	20%	26%	32%	39%	36%	40%	21%	30%	45%	100%

Commodity Delta – Risk Weights

The delta risk weights for Commodity risk depend on buckets. This is used in above Step b).

Bucket	Commodity	Risk Weight
1	Coal	48
2	Crude	29
3	Light Ends	33
4	Middle Distillates	25
5	Heavy Distillates	35
6	North America Natural Gas	30
7	European Natural Gas	60

Bucket	Commodity	Risk Weight
8	North American Power	52
9	European Power and Carbon	68
10	Freight	63
11	Base Metals	21
12	Precious Metals	21
13	Grains and Oilseed	15
14	Softs and Other Agriculturals	16
15	Livestock and Dairy	13
16	Other	68
17	Indexes	17

Commodity Delta – Concentration Thresholds

The delta concentration thresholds of Commodity risk depend on bucket. This is used in above Step b).

Bucket(s)	CT Bucket	Concentration Threshold (USD mm/%)
1	Coal	310
2	Crude Oil	2100
3-5	Oil Fractions	1700
6-7	Natural gas	2800
8-9	Power	2700
10	Freight, Dry or Wet	52
11	Base Metals	530
12	Precious Metals	1300
13-15	Agricultural	100
16	Other	52

Bucket(s)	CT Bucket	Concentration Threshold (USD mm/%)
17	Indices	4000

Commodity Delta – Correlation

The correlation ρ_{kl} of Commodity risk within the same bucket is defined in the following table. This is used in above Step c).

Bucket Number	Correlation
1	83%
2	97%
3	93%
4	97%
5	98%
6	90%
7	98%
8	49%
9	80%
10	46%
11	58%
12	53%
13	62%
14	16%
15	18%
16	0%
17	38%

The correlation γ_{bc} applying to different non-residual bucket is defined in the following table (in %).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	100	22	18	21	20	24	49	16	38	14	10	2	12	11	2	0	17
2	22	100	92	90	88	25	8	19	17	17	42	28	36	27	20	0	64
3	18	92	100	87	84	16	7	15	10	18	33	22	27	23	16	0	54
4	21	90	87	100	77	19	11	18	16	14	32	22	28	22	11	0	58
5	20	88	84	77	100	19	9	12	13	18	42	34	32	29	13	0	59
6	24	25	16	19	19	100	31	62	23	10	21	5	18	10	8	0	28
7	49	8	7	11	9	31	100	21	79	17	10	-8	10	7	-2	0	13
8	16	19	15	18	12	62	21	100	16	8	13	-7	7	5	2	0	19
9	38	17	10	16	13	23	79	16	100	15	9	-6	6	6	1	0	16
10	14	17	18	14	18	10	17	8	15	100	16	9	14	9	3	0	11
11	10	42	33	32	42	21	10	13	9	16	100	36	30	25	18	0	37
12	2	28	22	22	34	5	-8	-7	-6	9	36	100	20	18	11	0	26
13	12	36	27	28	32	18	10	7	6	14	30	20	100	28	19	0	39
14	11	27	23	22	29	10	7	5	6	9	25	18	28	100	13	0	26
15	2	20	16	11	13	8	-2	2	1	3	18	11	19	13	100	0	21
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
17	17	64	54	58	59	28	13	19	16	11	37	26	39	26	21	0	100

Non-IR Delta Margin Examples

FX Delta

Here is an example of FX delta margin calculation following Non-IR Delta Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Amount	AmountCurrency	AmountUSD
Risk_FX	EUR	-5,000,000,000	USD	-5,000,000,000
Risk_FX	EUR	-900,000,000	USD	-900,000,000
Risk_FX	EUR	-5,000,000,000	USD	-5,000,000,000
Risk_FX	EUR	-900,000,000	USD	-900,000,000
Risk_FX	EUR	-5,000,000,000	USD	-5,000,000,000
Risk_FX	EUR	-900,000,000	USD	-900,000,000
Risk_FX	EUR	-5,000,000,000	USD	-5,000,000,000
Risk_FX	EUR	-900,000,000	USD	-900,000,000
Risk_FX	EUR	-5,000,000,000	USD	-5,000,000,000
Risk_FX	EUR	-900,000,000	USD	-900,000,000
Risk_FX	EUR	-5,000,000,000	USD	-5,000,000,000
Risk_FX	EUR	-900,000,000	USD	-900,000,000

RiskType	Qualifier	Amount	AmountCurrency	AmountUSD
Risk_FX	EUR	-35,400,000,000	USD	=SUM(K15:K26)

b) Calculate **concentration risk factor** and **weighted sensitivities**.

=MAX(1,SQRT(ABS(B8)/B7))

Concentration Risk	GBP	EUR	CNY	KRW
Threshold	3300000000	3300000000	880000000	880000000
Sum of Sk	910,000,000	-900,000,000	-200,000,000	210,000,000
CR	1	1	1	1

RiskType	Qualifier	Amount	AmountCurrency	AmountUSD	FX Group	Weight	Concentration Risk	Weight*Sk*CR
Risk_FX	GBP	910,000,000	USD	910,000,000	Regular	7.4	1	=K15*M15*B9
Risk_FX	EUR	-900,000,000	USD	-900,000,000	Regular	7.4	1	-6660000000
Risk_FX	CNY	-200,000,000	USD	-200,000,000	Regular	7.4	1	-1480000000
Risk_FX	KRW	210,000,000	USD	210,000,000	Regular	7.4	1	1554000000

c) Calculate K for each currency.
In case of FX delta, K for each currency is the same amount of weighted sensitivities * concentration risk factors.

d) Calculate S for each currency and Delta Margin.

Calculation of Sb factor

ProductClass	Currency	k	k^2	Sum of WSk	Sb
RatesFX	GBP	6734000000	4.53468E+19	6734000000	6734000000
RatesFX	EUR	6660000000	4.43556E+19	-6660000000	-6660000000
RatesFX	CNY	1480000000	2.1904E+18	-1480000000	-1480000000
RatesFX	KRW	1554000000	2.41492E+18	1554000000	1554000000

RatesFX		Sb_1	Sb_2	CR_1	CR_2	Correlation	f_12	Production
GBP	GBP	6734000000	6734000000	1	1	100%	100%	0
GBP	EUR	6734000000	-6660000000	1	1	50%	100%	-2.24242E+19
GBP	CNY	6734000000	-1480000000	1	1	50%	100%	-4.98316E+18
GBP	KRW	6734000000	1554000000	1	1	50%	100%	5.23232E+18
EUR	GBP	-6660000000	6734000000	1	1	50%	100%	-2.24242E+19
EUR	EUR	-6660000000	-6660000000	1	1	100%	100%	0
EUR	CNY	-6660000000	-1480000000	1	1	50%	100%	4.9284E+18
EUR	KRW	-6660000000	1554000000	1	1	50%	100%	-5.17482E+18
CNY	GBP	-1480000000	6734000000	1	1	50%	100%	-4.98316E+18
CNY	EUR	-1480000000	-6660000000	1	1	50%	100%	4.9284E+18
CNY	CNY	-1480000000	-1480000000	1	1	100%	100%	0
CNY	KRW	-1480000000	1554000000	1	1	50%	100%	-1.14996E+18
KRW	GBP	1554000000	6734000000	1	1	50%	100%	5.23232E+18
KRW	EUR	1554000000	-6660000000	1	1	50%	100%	-5.17482E+18
KRW	CNY	1554000000	-1480000000	1	1	50%	100%	-1.14996E+18
KRW	KRW	1554000000	1554000000	1	1	100%	100%	0
							SUM	4.71648E+19
							Delta Margin	6867662484

FX delta margin in IM output file can be found in column Risk_FX.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_FX	RISK_FXVOL	RISK_FXCURVATURE	RISK_FXIM
ISDA-C78	USD	6.87E+09	Receive	All	RatesFX	6867662484	6867662484			6867662484
ISDA-C78	USD	6.87E+09	Receive	All	Credit	0				
ISDA-C78	USD	6.87E+09	Receive	All	Equity	0				
ISDA-C78	USD	6.87E+09	Receive	All	Commodi	0				

Credit Qualifying Delta

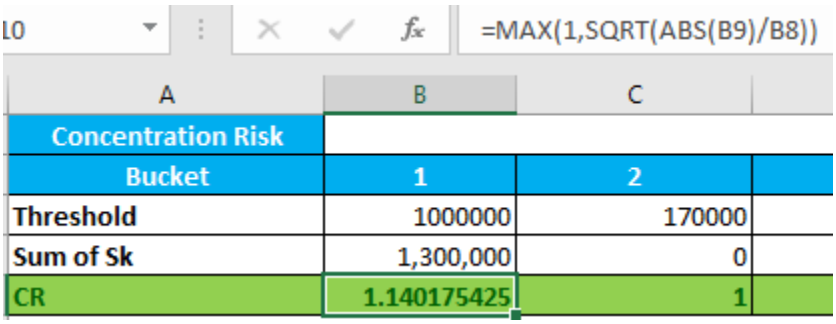
Here is an example of Credit Qualifying delta margin calculation following Non-IR Delta Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditQ	ISIN:BE0934259525	1	1y	USD	800,000	USD	800,000
Risk_CreditQ	ISIN:BE0934259525	1	1y	USD	800,000	USD	800,000
Risk_CreditQ	ISIN:BE0934259525	1	2y	USD	-300,000	USD	-300,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditQ	ISIN:BE0934259525	1	1y	USD	1,600,000	USD	=SUM(K16:K17)
Risk_CreditQ	ISIN:BE0934259525	1	2y	USD	-300,000	USD	-300,000

b) Calculate **concentration risk factor** and **weighted sensitivities**.



RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	Weight	Weight*Sk*CR
Risk_CreditQ	ISIN:BE0934259525	1	1y	USD	1,600,000	USD	1,600,000	ISIN:BE0934259525-1y-USD	75	136821051
Risk_CreditQ	ISIN:BE0934259525	1	2y	USD	-300,000	USD	-300,000	ISIN:BE0934259525-2y-USD	75	-25653947.06

c) Calculate K for each bucket.

Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	CR_1	CR_2	Correlation	f_12	Production
1	ISIN:BE0934259525	ISIN:BE0934259525-1y-USD	136,821,051	136,821,051	1.19522861	1.19522861	100%	1	1.872E+16
1	ISIN:BE0934259525	ISIN:BE0934259525-2y-USD	136,821,051	-25,653,947	1.19522861	1.19522861	93%	1	-3.2643E+15
1	ISIN:BE0934259525	ISIN:BE0934259525-1y-USD	-25,653,947	136,821,051	1.19522861	1.19522861	93%	1	-3.2643E+15
1	ISIN:BE0934259525	ISIN:BE0934259525-2y-USD	-25,653,947	-25,653,947	1.19522861	1.19522861	100%	1	6.58125E+14
								K-Bucket 1	113355745.3

d) Calculate S for each bucket and Delta Margin.

Bucket	k	k^2	Sum of WSk	Sb
1	60000000	3.6E+15	60000000	60000000
2	16669662.48	2.77878E+14	16669662.48	16669662.48
3	15558351.64	2.42062E+14	15558351.64	15558351.64
4	10001797.49	1.00036E+14	10001797.49	10001797.49
5	11483545.26	1.31872E+14	11483545.26	11483545.26
6	8890486.654	7.90408E+13	8890486.654	8890486.654

Bucket		Sb_1	Sb_2	correlation	Production
1	1	60000000	60000000	100%	0
1	2	60000000	16669662.48	38%	3.80068E+14
1	3	60000000	15558351.64	38%	3.5473E+14
1	4	60000000	10001797.49	35%	2.10038E+14
1	5	60000000	11483545.26	37%	2.54935E+14
1	6	60000000	8890486.654	34%	1.81366E+14
2	1	16669662.48	60000000	38%	3.80068E+14
2	2	16669662.48	16669662.48	100%	0
2	3	16669662.48	15558351.64	48%	1.24489E+14
2	4	16669662.48	10001797.49	46%	7.66942E+13
2	5	16669662.48	11483545.26	48%	9.18849E+13
2	6	16669662.48	8890486.654	46%	6.81726E+13
3	1	15558351.64	60000000	38%	3.5473E+14
3	2	15558351.64	16669662.48	48%	1.24489E+14
3	3	15558351.64	15558351.64	100%	0
3	4	15558351.64	10001797.49	50%	7.78057E+13
3	5	15558351.64	11483545.26	51%	9.11192E+13
3	6	15558351.64	8890486.654	50%	6.91607E+13
4	1	10001797.49	60000000	35%	2.10038E+14
4	2	10001797.49	16669662.48	46%	7.66942E+13
4	3	10001797.49	15558351.64	50%	7.78057E+13
4	4	10001797.49	10001797.49	100%	0
4	5	10001797.49	11483545.26	50%	5.7428E+13
4	6	10001797.49	8890486.654	50%	4.44604E+13
5	1	11483545.26	60000000	37%	2.54935E+14
5	2	11483545.26	16669662.48	48%	9.18849E+13
5	3	11483545.26	15558351.64	51%	9.11192E+13
5	4	11483545.26	10001797.49	50%	5.7428E+13
5	5	11483545.26	11483545.26	100%	0
5	6	11483545.26	8890486.654	50%	5.10472E+13
6	1	8890486.654	60000000	34%	1.81366E+14
6	2	8890486.654	16669662.48	46%	6.81726E+13
6	3	8890486.654	15558351.64	50%	6.91607E+13
6	4	8890486.654	10001797.49	50%	4.44604E+13
6	5	8890486.654	11483545.26	50%	5.10472E+13
6	6	8890486.654	8890486.654	100%	0
				SUM	4.2668E+15
				SUM of K^2	4.43089E+15
				Delta Margin	93261390.4

Credit Qualifying delta margin in IM output file can be found in column Risk_CREDITQ.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_CREDITQ	RISK_CREDITVOL	RISK_CREDITCURVATURE	RISK_BASECORR	RISK_CRIM
ISDA-C123	USD	93261390	Receive	All	RatesFX	0					
ISDA-C123	USD	93261390	Receive	All	Credit	93261390.4	93261390.4				93261390.4
ISDA-C123	USD	93261390	Receive	All	Equity	0					
ISDA-C123	USD	93261390	Receive	All	Commodi	0					

Credit Non-Qualifying Delta

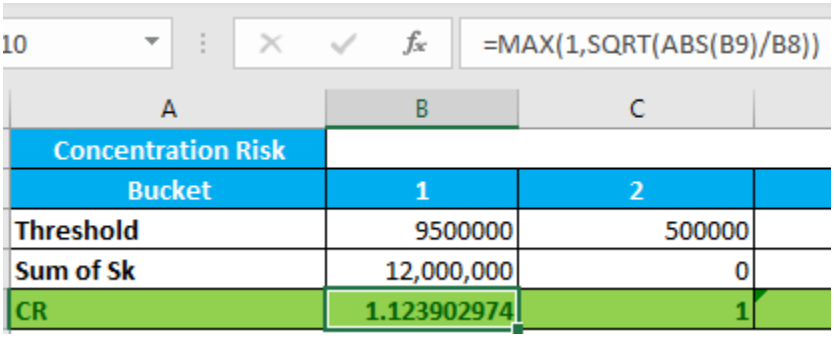
Here is an example of Credit Non-Qualifying delta margin calculation following Non-IR Delta Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditNonQ	ISIN:AU3005621011	1	1y	CMBX	6,000,000	USD	6,000,000
Risk_CreditNonQ	ISIN:AU3005621011	1	2y	CMBX	3,000,000	USD	3,000,000
Risk_CreditNonQ	ISIN:AU3005621011	1	2y	CMBX	3,000,000	USD	3,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditNonQ	ISIN:AU3005621011	1	1y	CMBX	6,000,000	USD	6,000,000
Risk_CreditNonQ	ISIN:AU3005621011	1	2y	CMBX	6,000,000	USD	=SUM(K17:K18)

b) Calculate **concentration risk factor** and **weighted sensitivities**.



RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	Weight	Weight*Sk*CR
Risk_CreditNonQ	ISIN:AU3005621011	1	1y	CMBX	6,000,000	USD	6,000,000	ISIN:AU3005621011-1y-CMBX	280	1888156996
Risk_CreditNonQ	ISIN:AU3005621011	1	2y	CMBX	6,000,000	USD	6,000,000	ISIN:AU3005621011-2y-CMBX	280	1888156996

c) Calculate K for each bucket.

Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	CR_1	CR_2	Correlation	f_12	Production
1	ISIN:AU3005621011	ISIN:AU3005621011-1y-CM	1,888,156,996	1,888,156,996	1.123902974	1.123902974	100%	1	3.56514E+18
1	ISIN:AU3005621011	ISIN:AU3005621011-2y-CM	1,888,156,996	1,888,156,996	1.123902974	1.123902974	83%	1	2.95906E+18
1	ISIN:AU3005621011	ISIN:AU3005621011-1y-CM	1,888,156,996	1,888,156,996	1.123902974	1.123902974	83%	1	2.95906E+18
1	ISIN:AU3005621011	ISIN:AU3005621011-2y-CM	1,888,156,996	1,888,156,996	1.123902974	1.123902974	100%	1	3.56514E+18
								K-Bucket 1	3612257029

d) Calculate S for each bucket and Delta Margin.

Bucket	k	k^2	Sum of WSk	Sb
1	840000000	7.056E+17	840000000	840000000
2	260000000	6.76E+16	-260000000	-260000000
Residual	520000000	2.704E+17	520000000	520000000

Bucket		Sb_1	Sb_2	Correlation	Production
1	1	840000000	840000000	100%	0
1	2	840000000	-260000000	43%	-9.3912E+16
2	1	-260000000	840000000	43%	-9.3912E+16
2	2	-260000000	-260000000	100%	0

SUM	-1.87824E+17
SUM of K^2	7.732E+17
K-Bucket Residual	520000000
Delta Margin	1285098686

Credit Non-Qualifying delta margin in IM output file can be found in column Risk_CREDITNONQ.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_CREDITNONQ	RISK_CREDITVOLNONQ	RISK_CREDITNONQCURVATURE	RISK_CRNQIM
ISDA-C162	USD	1.29E+09	Receive	All	RatesFX	0				
ISDA-C162	USD	1.29E+09	Receive	All	Credit	1285098686	1285098686			1285098686
ISDA-C162	USD	1.29E+09	Receive	All	Equity	0				
ISDA-C162	USD	1.29E+09	Receive	All	Commodi	0				

Equity Delta

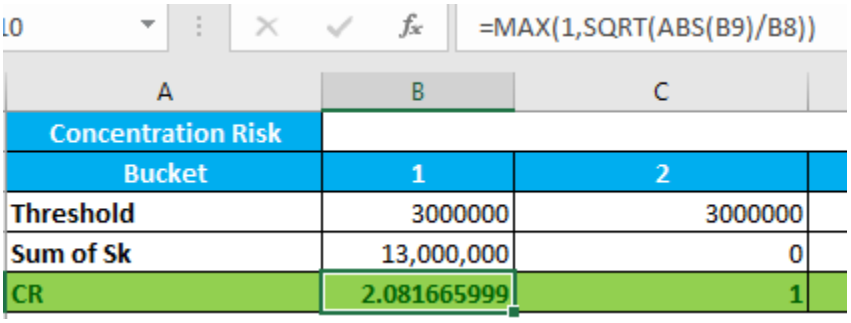
Here is an example of Equity delta margin calculation following Non-IR Delta Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_Equity	ISIN:US1266501006	5			10,000,000	USD	10,000,000
Risk_Equity	ISIN:US1266501006	5			10,000,000	USD	10,000,000
Risk_Equity	ISIN:US1266501006	5			10,000,000	USD	10,000,000
Risk_Equity	ISIN:US1266501006	5			10,000,000	USD	10,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_Equity	ISIN:US1266501006	5			40,000,000	USD	=SUM(K16:K19)

b) Calculate **concentration risk factor** and **weighted sensitivities**.



RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	Qualifier-Bucket	Weight	Weight*Sk*CR
Risk_Equity	ISIN:INE044A01036	1			12,000,000	USD	12,000,000	ISIN:INE044A01036-1	30	720000000
Risk_Equity	ISIN:INE406A01037	1			1,000,000	USD	1,000,000	ISIN:INE406A01037-1	30	30000000

c) Calculate K for each bucket.

Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	CR_1	CR_2	Correlation	f_12	Production
1	ISIN:INE044A01036-1	ISIN:INE044A01036-1	720,000,000	720,000,000	2.00000000	2.00000000	100%	1	5.184E+17
1	ISIN:INE044A01036-1	ISIN:INE406A01037-1	720,000,000	30,000,000	2.00000000	1.00000000	18%	0.5	1.944E+15
1	ISIN:INE406A01037-1	ISIN:INE044A01036-1	30,000,000	720,000,000	1.00000000	2.00000000	18%	0.5	1.944E+15
1	ISIN:INE406A01037-1	ISIN:INE406A01037-1	30,000,000	30,000,000	1.00000000	1.00000000	100%	1	9E+14
								K-Bucket 1	723317357.7

d) Calculate S for each bucket and Delta Margin.

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Equity	1	254558441.2	6.48E+16	254558441.2	254558441.2
Equity	2	66000000	4.356E+15	-66000000	-66000000

Bucket		Sb_1	Sb_2	correlation	Production
1	1	254558441.2	254558441.2	100%	0
1	2	254558441.2	-66000000	18%	-3.02415E+15
2	1	-66000000	254558441.2	18%	-3.02415E+15
2	2	-66000000	-66000000	100%	0
				SUM	-6.04831E+15
				SUM of K^2	6.9156E+16
				Residual K	29061909.69
				Delta Margin	280274352.5

Equity delta margin in IM output file can be found in column Risk_EQUITY.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_EQUITY	RISK_EQUITYVOL	RISK_EQUITYCURVATURE	RISK_EQIM
ISDA-C221	USD	2.12E+10	Receive	All	RatesFX	0				
ISDA-C221	USD	2.12E+10	Receive	All	Credit	0				
ISDA-C221	USD	2.12E+10	Receive	All	Equity	21156037372	21156037372			21156037372
ISDA-C221	USD	2.12E+10	Receive	All	Commodi	0				

Commodity Delta

Here is an example of Commodity delta margin calculation following Non-IR Delta Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_Commodity	Coal Americas	1			1,500,000,000	USD	=SUM(K16:K25)

b) Calculate **concentration risk factor** and **weighted sensitivities**.

10 =MAX(1,SQRT(ABS(B9)/B8))

A	B	C
Concentration Risk		
Bucket	**1**	**2**
Threshold	310000000	2100000000
Sum of Sk	151,000,000	0
CR	1	1

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	Qualifier-Bucket	Weight	Weight*Sk*CR
Risk_Commodity	Coal Americas	1			150,000,000	USD	150,000,000	Coal Americas-1	48	7200000000
Risk_Commodity	Coal Europe	1			1,000,000	USD	1,000,000	Coal Europe-1	48	48000000

c) Calculate K for each bucket.

Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	CR_1	CR_2	Correlation	f_12	Production
1	Coal Americas-1	Coal Americas-1	7,200,000,000	7,200,000,000	1.0	1.0	100%	1	5.184E+19
1	Coal Americas-1	Coal Europe-1	7,200,000,000	48,000,000	1.0	1.0	83%	1	2.86848E+17
1	Coal Europe-1	Coal Americas-1	48,000,000	7,200,000,000	1.0	1.0	83%	1	2.86848E+17
1	Coal Europe-1	Coal Europe-1	48,000,000	48,000,000	1.0	1.0	100%	1	2.304E+15
								K-Bucket 1	7239889502

d) Calculate S for each bucket and Delta Margin.

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Commodity	2	43500000000	1.89225E+21	43500000000	43500000000
Commodity	3	11880000000	1.41134E+20	-11880000000	-11880000000
Commodity	16	136000000	1.8496E+16	-136000000	-136000000

Bucket		Sb_1	Sb_2	correlation	Production
2	2	43500000000	43500000000	100%	0
2	3	43500000000	-11880000000	92%	-4.75438E+20
2	16	43500000000	-136000000	0%	0
3	2	-11880000000	43500000000	92%	-4.75438E+20
3	3	-11880000000	-11880000000	100%	0
3	16	-11880000000	-136000000	0%	0
16	2	-136000000	43500000000	0%	0
16	3	-136000000	-11880000000	0%	0
16	16	-136000000	-136000000	100%	0
				SUM	-9.50875E+20
				SUM of K^2	2.0334E+21
				Delta Margin	32901788644

Commodity delta margin in IM output file can be found in column Risk_COMMODITY.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_COMMODITY	RISK_COMMODITYVOL	RISK_COMMODITYCURVATURE	RISK_COMMODITYIM
ISDA-C288	USD	3.29E+10	Receive	All	RatesFX	0				
ISDA-C288	USD	3.29E+10	Receive	All	Credit	0				
ISDA-C288	USD	3.29E+10	Receive	All	Equity	0				
ISDA-C288	USD	3.29E+10	Receive	All	Commodi	32901788644	32901788644			32901788644

2.2.2 Vega Margin

Vega margin for **Interest Rate** is calculated based on risk types Risk_IRVol and Risk_InflationVol.

Vega margin for **FX** is calculated based on risk type Risk_FXVol.

Vega margin for **Credit Qualifying** is calculated based on risk type Risk_CreditVol.

Vega margin for **Credit Non-Qualifying** is calculated based on risk type Risk_CreditVolNonQ.

Vega margin for **Equity** is calculated based on risk type Risk_EquityVol.

Vega margin for **Commodity** is calculated based on risk type Risk_CommodityVol.

2.2.2.1 Vega Margin Step by Step Formula

The following is step by step approach of Vega Margin calculation.

a) Calculate **aggregated sensitivities** VR_{ik} with same risk type, qualifier, bucket, label1 and label2 for each product class and margin account. Here the vega risk VR_{ik} is estimated using the formula.
For **Interest Rate** and **Credit**:

$$VR_{ik} = \sum_j \sigma_{kj} \frac{\partial V_i}{\partial \sigma}$$

where σ_{kj} is the implied at-the-money volatility for risk factor k and maturity j. $\partial V_i / \partial \sigma$ is the vega. Risk_IRVol, Risk_InflationVol, Risk_CreditVol and Risk_CreditVolNonQ are the calculated sensitivities VR_{ik}.

For **Equity, Commodity** and **FX**:

$$VR_{ik} = HVR_c \sum_j \sigma_{kj} \frac{\partial V_i}{\partial \sigma}$$

$$\sigma_{kj} = \frac{RW_k \sqrt{365/14}}{\alpha}$$

where $\alpha = \Phi^{-1}(99\%)$ is the 99th percentile of the cumulative standard normal distribution and RW_k is the corresponding delta risk weights. For **FX** Vega, which depends on a currency pair, the risk weight to use is from FX delta weight table, given in FX Vega Risk Weights, whose row is the first currency and whose column is second currency of the currency pair. HVR_c is the historical volatility ratio for the risk class, which corrects the inaccuracy in the volatility estimate σ_{kj}. Risk_FXVol, Risk_EquityVol and Risk_CommodityVol are the calculated vega $\partial V_i / \partial \sigma$.

b) Calculate vega **concentration risk factor** VCR_b based on their threshold levels and **weighted sensitivities** VR_k based on weights of different risk classes.
For **Interest Rate** vega risk:

$$VR_k = VRW \left(\sum_i VR_{ik} \right) VCR_b$$

$$VCR_b = \max \left(1, \left(\frac{|\sum_{ik} VR_{ik}|}{VT_b} \right)^{\frac{1}{2}} \right)$$

where b is the bucket which contains the risk factor k.

For Credit spread vega risk:

$$VR_k = VRW \left(\sum_i VR_{ik} \right) VCR_k$$

$$VCR_k = \max \left(1, \left(\frac{|\sum_{ij} VR_{ij}|}{VT_b} \right)^{\frac{1}{2}} \right)$$

Where the sum j is taken over tenors of the same issuer/seniority curves as the risk factor k, irrespective of the tenor or payment currency.

For Equity, FX, Commodity vega risk:

$$VR_k = VRW \left(\sum_i VR_{ik} \right) VCR_k$$

$$VCR_k = \max \left(1, \left(\frac{|\sum_i VR_{ik}|}{VT_b} \right)^{\frac{1}{2}} \right)$$

Here VRW is the vega risk weight for the risk class concerned. VT_b is the vega concentration threshold for bucket (or FX category) b.

c) Calculate K , which is the weighted sensitivities being aggregated within each bucket b.

$$K_b = \sqrt{\sum_k VR_k^2 + \sum_k \sum_{l \neq k} \rho_{kl} f_{kl} VR_k VR_l}$$

where ρ_{kl} is the tenor correlation, inner correlation adjustment factors f_{kl} are defined to be identically 1 in the interest rate risk class and all other risk classes are defined to be:

$$f_{kl} = \frac{\min(VCR_k, VCR_l)}{\max(VCR_k, VCR_l)}$$

d) Calculate Vega Margin, which should be aggregated across buckets within each risk class.

$$Vega\ Margin = \sqrt{\sum_b K_b^2 + \sum_b \sum_{b \neq c} \gamma_{bc} g_{bc} S_b S_c} + K_{residual}$$

where

$$S_b = max\left(min\left(\sum_{k=1}^{K} VR_k, K_b\right), -K_b\right)$$

and γ_{bc} is the correlation parameters for each risk class, the outer correlation adjustment factor g_{bc} are identically 1 for all risk classes other than interest rates, and for interest rates they are defined to be:

$$g_{bc} = \frac{min(VCR_b, VCR_c)}{max(VCR_b, VCR_c)}$$

2.2.2.2 Vega Margin Static Data

Below is the static data used to calculate vega margin, based on ISDA version 2.6 (effective on Dec 2023).

Interest Rate Vega

Risk Weights

The vega risk weight, VRW, for interest rate is 0.23. This is used in above Step b).

The historical volatility ratio, HVR, for interest rate is 0.47. This is used in curvature margin Step e)

Concentration Threshold

The vega concentration thresholds for interest rate risk are given by currency groups. This is used in above Step b).

Currency Group	Currencies	Concentration Threshold (USD mm)
High Volatility	All other currencies	74

Currency Group	Currencies	Concentration Threshold (USD mm)
Regular Volatility, well-traded	USD, EUR, GBP	4900
Regular Volatility, less well-traded	AUD, CAD, CHF, DKK, HKD, KRW, NOK, NZD, SEK, SGD, TWD	520
Low Volatility	JPY	970

Correlation

The correlation used for IR vega calculation is the same as IR delta, see Interest Rate Delta – Correlation.

FX Vega

Risk Weights

Risk weight used to calculate FX volatility in step a) is the same risk weighs used in FX delta calculation, whose row is the first currency and whose column is second currency of the currency pair.

High FX volatility currencies: BRL, RUB, TRY.

Regular FX volatility currencies: all other currencies.

FX Volatility Group	Regular (second ccy)	High (second ccy)
Regular (first ccy)	7.4	14.7
High (fisrt ccy)	14.7	21.4

The vega risk weight, VRW, for FX is 0.48. This is used in above Step b).

The historical volatility ratio, HVR, for FX is 0.47. This is used in above Step a).

Concentration Threshold

The vega concentration thresholds for FX vega are shown as below. This is used in above Step b).

Category 1 – Significantly material: USD, EUR, JPY, GBP, AUD, CHF, CAD

Category 2 – Frequently traded: BRL, CNY, HKD, INR, KRW, MXN, NOK, NZD, RUB, SEK, SGD, TRY, ZAR

Category 3 – Others: All other currencies

FX Risk Group	Concentration Threshold (USD mm)
Category 1 – Category 1	2800
Category 1 – Category 2	1400
Category 1 – Category 3	590
Category 2 – Category 2	520
Category 2 – Category 3	340
Category 3 – Category 3	210

Correlation

The correlation used for FX pair of vega and curvature is 0.5.

Credit Vega

Risk Weights

The vega risk weight, VRW, for credit qualifying is 0.76. This is used in above Step b).

The vega risk weight, VRW, for credit non-qualifying is 0.76. This is used in above Step b).

Concentration Threshold

The vega concentration thresholds for credit risk (including the residual buckets) are shown as below. This is used in above Step b).

Credit Risk Group	Concentration Threshold (USD mm)
Qualifying	360
Non-Qualifying	70

Correlation

The correlation used for credit vega and curvature calculation is the same as credit delta, see Credit Qualifying Delta – Correlation and Credit Non-Qualifying Delta – Correlation.

Equity Vega

Risk Weights

Risk weight used to calculate Equity volatility in step a) is the same risk weighs used in Equity delta calculation for each bucket, see Equity Delta – Risk Weights.

The vega risk weight, VRW, for Equity is 0.45 for all buckets except bucket 12. This is used in above Step b).

The vega risk weight, VRW, for Equity is 0.96 for bucket 12. This is used in above Step b).

The historical volatility ratio, HVR, for Equity is 0.6. This is used in above Step a).

Concentration Threshold

The vega concentration thresholds for Equity are shown as below. This is used in above Step b).

Bucket(s)	Equity Risk Group	Concentration Threshold (USD mm)
1-4	Emerging Markets – Large Cap	210
5-8	Developed Markets – Large Cap	1300
9	Emerging Markets – Small Cap	39
10	Developed Markets – Small Cap	190
11-12	Indexes, Funds, ETFs, Volatility Indexes	6400
Residual	Not classified	39

Correlation

The correlation used for Equity vega and curvature calculation is the same as equity delta, see Equity Delta – Correlation.

Commodify Vega

Risk Weights

Risk weight used to calculate commodity volatility in step a) is the same risk weighs used in commodity delta calculation for each bucket, see Commodity Delta – Risk Weights.

The vega risk weight, VRW, for Commodity is 0.55. This is used in above Step b).

The historical volatility ratio, HVR, for Commodity is 0.74. This is used in above Step a).

Concentration Threshold

The vega concentration thresholds for commodity are shown as below. This is used in above Step b).

Bucket(s)	CT Bucket	Concentration Threshold (USD mm)
1	Coal	390
2	Crude Oil	2900
3-5	Oil Fractions	310
6-7	Natural gas	6300
8-9	Power	1200
10	Freight, Dry or Wet	120
11	Base Metals	390
12	Precious Metals	1300
13-15	Agricultural	590
16	Other	69
17	Indices	69

Correlation

The correlation used for commodity vega and curvature calculation is the same as commodity delta, see Commodity Delta – Correlation.

2.2.2.3 Vega Margin Examples

Interest Rate Vega

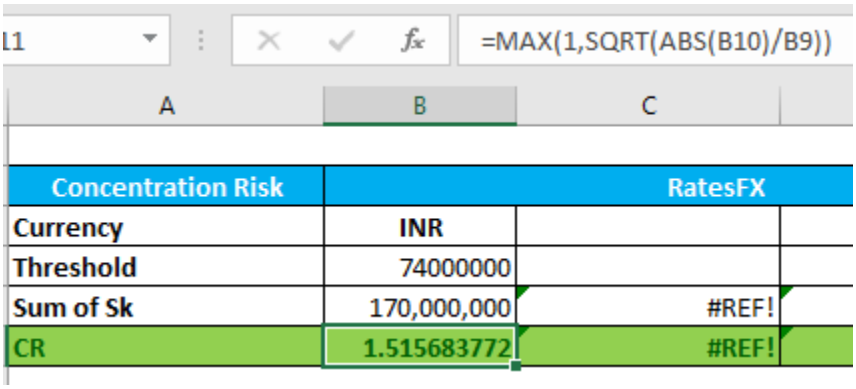
Here is an example of interest rate vega margin calculation following Vega Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_IRVol	INR		5y		80,000,000	USD	80,000,000
Risk_IRVol	INR		5y		80,000,000	USD	80,000,000
Risk_InflationVol	INR		5y		10,000,000	USD	10,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_IRVol	INR		5y		160,000,000	USD	=SUM(K16:K17)
Risk_InflationVol	INR		5y		10,000,000	USD	10,000,000

b) Calculate **concentration risk factor** and **weighted sensitivities**.



L1	=MAX(1,SQRT(ABS(B10)/B9))	
	A	B	C
	Concentration Risk	RatesFX	
	Currency	INR	
	Threshold	74000000	
	Sum of Sk	170,000,000	#REF!
	CR	1.515683772	#REF!

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	Tenor	Weight (VRW)	Weighted Sk	Weight*Sk*CR
Risk_IRVol	INR		5y		160,000,000	USD	160,000,000	Risk_IRVol-5y	0.23	36800000	=K21*M21*S11
Risk_InflationVol	INR		5y		10,000,000	USD	10,000,000	Risk_InflationVol-5y	0.23	2300000	3486072.676

c) Calculate K for each currency. Adjustment factor for interest rate vega is always 1.

ProductClass	Currency	Tenor Sk	Tenor Sl	Wsk	Wsl	Correlation	Adjustment factor	Production
RatesFX	INR	Risk_IRVol-5y	Risk_IRVol-5y	55,777,163	55,777,163	100%	1.00	3.11109E+15
RatesFX	INR	Risk_IRVol-5y	Risk_InflationVol-5y	55,777,163	3,486,073	24%	1.00	=E29*F29*G29*H29
RatesFX	INR	Risk_InflationVol-5y	Risk_IRVol-5y	3,486,073	55,777,163	24%	1.00	4.66664E+13
RatesFX	INR	Risk_InflationVol-5y	Risk_InflationVol-5y	3,486,073	3,486,073	100%	1.00	1.21527E+13
							K-INR	56714877.69

d) Calculate S for each currency and Vega Margin.

Calculation of Sb factor

ProductClass	Currency	k	k^2	Sum of WSk	Sb
RatesFX	USD	161000000	2.5921E+16	161000000	161000000
RatesFX	JPY	46000000	2.116E+15	46000000	46000000
RatesFX	CAD	57500000	3.30625E+15	57500000	57500000

RatesFX		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
USD	USD	161000000	161000000	1	1	100%	1.00	0
USD	JPY	161000000	46000000	1	1	32%	1.00	2.36992E+15
USD	CAD	161000000	57500000	1	1	32%	1.00	2.9624E+15
JPY	USD	46000000	161000000	1	1	32%	1.00	2.36992E+15
JPY	JPY	46000000	46000000	1	1	100%	1.00	0
JPY	CAD	46000000	57500000	1	1	32%	1.00	8.464E+14
CAD	USD	57500000	161000000	1	1	32%	1.00	2.9624E+15
CAD	JPY	57500000	46000000	1	1	32%	1.00	8.464E+14
CAD	CAD	57500000	57500000	1	1	100%	1.00	0
							SUM	1.23574E+16
							SUM of K^2	3.13433E+16
							Vega Margin	209047100

Interest Rate vega margin in IM output file can be found in column Risk_IRVOL.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_F	RISK_F	RISK_F	RISK_F	RISK_IR	RISK_IRCURVATURE	RISK_IRVOL	RISK_IRIM
ISDA-C334	USD	2.29E+08	Receive	All	RatesFX	229493240.9						20446140.97	209047100	229493240.9
ISDA-C334	USD	2.29E+08	Receive	All	Credit	0								
ISDA-C334	USD	2.29E+08	Receive	All	Equity	0								
ISDA-C334	USD	2.29E+08	Receive	All	Commodi	0								

FX Vega

Here is an example of FX vega margin calculation following Vega Margin Step by Step Formula.

a) Calculate **aggregated sensitivities** for each currency pair regardless of tenor.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000
Risk_FXVol	HKDKRW		6m		-15,000,000	USD	-15,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_FXVol	HKDKRW		6m		-150,000,000	USD	=SUM(K17:K26)

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_FXVol	USDGBP		3m		24,000,000	USD	24,000,000
Risk_FXVol	USDGBP		1y		-24,000,000	USD	-24,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_FXVol	USDGBP				0	USD	=SUM(K17:K18)

b) Calculate HVR and **volatilities** σ_{kj}, **concentration risk factor** and **weighted sensitivities**.

1 | f_x =MAX(1,SQRT(ABS(B10)/B9))

A	B	C
Concentration Risk		RatesFX
Qualifier	BRLUSD	EURQAR
Threshold	1,400,000,000	590,000,000
Sum of HVR*Vol*Sk	1,471,261,714	-185,158,787
CR	1.025134735	1

AmountUSD	Qualifier-tenor	HVR	Weight (RW)	alpha	volatility	Weight (VRW)	HVR*Vol*Sk (VR)	HVR*Vol*Weight*Sk*CR
80,000,000	BRLUSD-2y	0.57	14.7	2.33	32.26	0.48	1471261714	=Q17*R17*B11
-20,000,000	EURQAR-1m	0.57	7.4	2.33	16.24	0.48	-185158787.1	-88876217.82

c) Calculate K for each currency pair.

ProductClass	Qualifier	Qualifier-tenor Sk	Qualifier-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
RatesFX	BRLUSD	BRLUSD-2y	BRLUSD-2y	723,955,914	723,955,914	100%	1.03	1.03	1.00	5.24112E+17
									K-BRLUSD	723955913.7

ProductClass	Qualifier	Qualifier-tenor Sk	Qualifier-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
RatesFX	EURQAR	EURQAR-1m	EURQAR-1m	-88,876,218	-88,876,218	100%	1.00	1.00	1.00	7.89898E+15
									K-EURQAR	88876217.82

d) Calculate S for each currency and Vega Margin.

ProductClass	Qualifier	k	k^2	Sum of WSk	Sb
RatesFX	BRLUSD	723955913.7	5.24112E+17	723955913.7	723955913.7
RatesFX	EURQAR	88876217.82	7.89898E+15	-88876217.82	-88876217.82

Qualifier		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
BRLUSD	BRLUSD	723955913.7	723955913.7	1.025134735	1.025134735	100%	1.00	0
BRLUSD	EURQAR	723955913.7	-88876217.82	1.025134735	1	50%	0.98	-3.13824E+16
EURQAR	BRLUSD	-88876217.82	723955913.7	1	1.025134735	50%	0.98	-3.13824E+16
EURQAR	EURQAR	-88876217.82	-88876217.82	1	1	100%	1.00	0
							SUM	-6.27649E+16
							SUM of K^2	5.32011E+17
							Vega Margin	685015519.7

FX vega margin in IM output file can be found in column Risk_FXVOL.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_FX	RISK_FXVOL	RISK_FXCURVATURE	RISK_FXIM
ISDA-C35	USD	8.75E+08	Receive	All	RatesFX	875124274.8		685015519.7	190108755.1	875124274.8
ISDA-C35	USD	8.75E+08	Receive	All	Credit	0				
ISDA-C35	USD	8.75E+08	Receive	All	Equity	0				
ISDA-C35	USD	8.75E+08	Receive	All	Commodi	0				

Credit Qualifying Vega

Here is an example of credit qualifying vega margin calculation following Vega Margin Step by Step Formula.

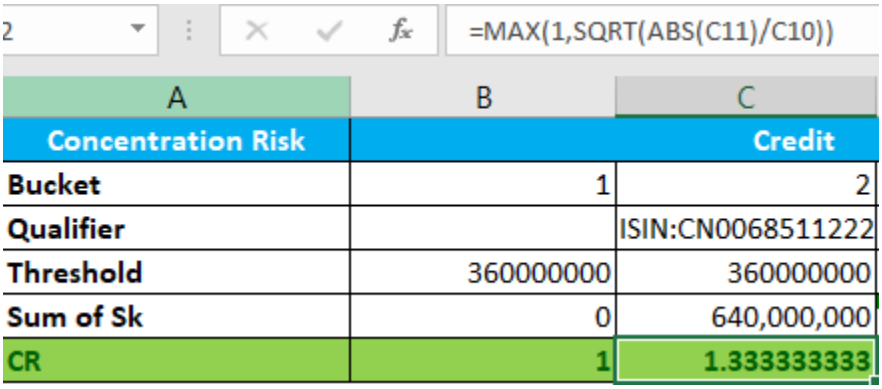
a) Calculate **aggregated sensitivities**.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditVol	ISIN:CN0068511222	2	1y	CNY	200,000,000	USD	200,000,000
Risk_CreditVol	ISIN:CN0068511222	2	1y	CNY	200,000,000	USD	200,000,000
Risk_CreditVol	ISIN:CN0068511222	2	1y	CNY	200,000,000	USD	200,000,000
Risk_CreditVol	ISIN:CN0068511222	2	1y	CNY	200,000,000	USD	200,000,000
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-40,000,000	USD	-40,000,000
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-40,000,000	USD	-40,000,000
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-40,000,000	USD	-40,000,000
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-40,000,000	USD	-40,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditVol	ISIN:CN0068511222	2	1y	CNY	800,000,000	USD	=SUM(K18:K21)
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-160,000,000	USD	

SUM(**number1**, [number2], ...

b) Calculate **concentration risk factor** and **weighted sensitivities**. Concentration risk factor is calculated for each qualifier (ISIN number) in same bucket.



RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	Weight (VRW)	Weighted Sk	Weight*Sk*CR
Risk_CreditVol	ISIN:CN0068511222	2	1y	CNY	800,000,000	USD	800,000,000	ISIN:CN0068511222-1y-CNY	0.76	608000000	=K29*M29*C12
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-160,000,000	USD	-160,000,000	ISIN:CN0068511222-2y-CNY	0.76	-121600000	-162133333.3

c) Calculate K for each bucket.

ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor(f_12	Production
Credit	2	:CN0068511222-1y-	ISIN:CN0068511222-1y-CNY	810,666,667	810,666,667	100%	133%	133%	1.00	=E36*F36*G36*J36
Credit	2	:CN0068511222-1y-	ISIN:CN0068511222-2y-CNY	810,666,667	-162,133,333	93%	133%	133%	1.00	-1.22236E+17
Credit	2	:CN0068511222-2y-	ISIN:CN0068511222-1y-CNY	-162,133,333	810,666,667	93%	133%	133%	1.00	-1.22236E+17
Credit	2	:CN0068511222-2y-	ISIN:CN0068511222-2y-CNY	-162,133,333	-162,133,333	100%	133%	133%	1.00	2.62872E+16
									K-Bucket 2	662568137.5

d) Calculate S for each non-residual bucket and Vega Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Credit	1	91200000	8.31744E+15	91200000	91200000
Credit	2	30400000	9.2416E+14	-30400000	-30400000

Bucket		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
1	1	91200000	91200000	1	1	100%	1.00	0
1	2	91200000	-30400000	1	1	38%	1.00	-1.05354E+15
2	1	-30400000	91200000	1	1	38%	1.00	-1.05354E+15
2	2	-30400000	-30400000	1	1	100%	1.00	0
							SUM	-2.10708E+15
							SUM of K^2	9.2416E+15
							K-Bucket Residual	7600000
							Vega Margin	92066059.46

Credit Qualifying vega margin in IM output file can be found in column Risk_CREDITVOL.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_CREDITQ	RISK_CREDITVOL	RISK_CREDITCURVATURE	RISK_B	RISK_C
ISDA-C38(	USD	1.08E+08	Receive	All	RatesFX	0					
ISDA-C38(	USD	1.08E+08	Receive	All	Credit	108091631		92066059.46	16025571.55		1.08E+08
ISDA-C38(	USD	1.08E+08	Receive	All	Equity	0					
ISDA-C38(	USD	1.08E+08	Receive	All	Commodi	0					

Credit Non-Qualifying Vega

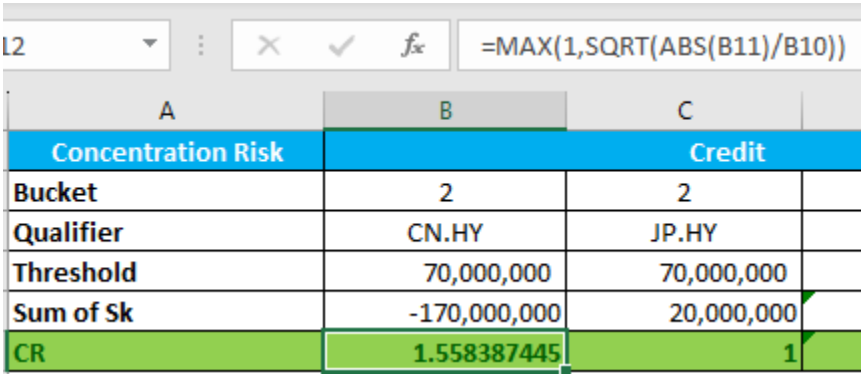
Here is an example of credit non-qualifying vega margin calculation following Vega Margin Step by Step Formula.

a) Calculate **aggregated sensitivities**.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditVolNonQ	CN.HY	2	3y	CMBX	-85,000,000	USD	-85,000,000
Risk_CreditVolNonQ	CN.HY	2	3y	CMBX	-85,000,000	USD	-85,000,000
Risk_CreditVolNonQ	JP.HY	2	5y	ABX	20,000,000	USD	20,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CreditVolNonQ	CN.HY	2	3y	CMBX	-170,000,000	USD	=SUM(K18:K19)
Risk_CreditVolNonQ	JP.HY	2	5y	ABX	20,000,000	USD	SUM(**number1**, [number2]

b) Calculate **concentration risk factor** and **weighted sensitivities**. Concentration risk factor is calculated for each qualifier in same bucket.



RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	Weight (VRW)	Weighted Sk	Weight*Sk*CR
Risk_CreditVolNonQ	CN.HY	2	3y	CMBX	-170,000,000	USD	-170,000,000	CN.HY-3y-CMBX	0.76	-129200000	=K24*M24*$BS12
Risk_CreditVolNonQ	JP.HY	2	5y	ABX	20,000,000	USD	20,000,000	JP.HY-5y-ABX	0.76	15200000	15200000

c) Calculate K for each bucket.

ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Credit	2	CN.HY-3y-CMBX	CN.HY-3y-CMBX	-201,343,658	-201,343,658	100%	1.56	1.56	1.00	4.05393E+16
Credit	2	CN.HY-3y-CMBX	JP.HY-5y-ABX	-201,343,658	15,200,000	32%	1.56	1.00	0.64	-6.28429E+14
Credit	2	JP.HY-5y-ABX	CN.HY-3y-CMBX	15,200,000	-201,343,658	32%	1.00	1.56	0.64	-6.28429E+14
Credit	2	JP.HY-5y-ABX	JP.HY-5y-ABX	15,200,000	15,200,000	100%	1.00	1.00	1.00	2.3104E+14
									K-Bucket 2	198779905.9

d) Calculate S for each non-residual bucket and Vega Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Credit	1	13251052.79	1.7559E+14	7600000	7600000

Bucket		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
1	1	7600000	7600000	1	1	100%	1.00	0
							SUM	0
							SUM of K^2	1.7559E+14
							K-Bucket Residual	71185732.92
							Vega Margin	84436785.71

Credit Non-Qualifying vega margin in IM output file can be found in column Risk_CREDITVOLNONQ.

Portfol	Curren	Total In	IM_DIR	REGULA	Produc	RISK_IM	RISK_CREDITNONQ	RISK_CREDITVOLNONQ	RISK_CREDITNONQCURVATURE	RISK_CRNQIM
ISDA-C400	USD	98253624	Receive	All	RatesFX	0				
ISDA-C400	USD	98253624	Receive	All	Credit	98253623.69		84436785.71	13816837.98	98253623.69
ISDA-C400	USD	98253624	Receive	All	Equity	0				
ISDA-C400	USD	98253624	Receive	All	Commodi	0				

Equity Vega

Here is an example of equity vega margin calculation following Vega Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000
Risk_EquityVol	ISIN:AU002189533177	5	3y		15,000,000	USD	15,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_EquityVol	ISIN:AU002189533177	5	3y		300,000,000	USD	=SUM(K17:K36)

b) Calculate HVR and **volatilities** σ_{kj}, **concentration risk factor** and **weighted sensitivities**.

I1 =MAX(1,SQRT(ABS(B10)/B9))

A	B	C
Concentration Risk		Equity
Bucket	5	
Threshold	1,300,000,000	
Sum of HVR*Vol*Sk	10,271,966,854	#REF!
CR	2.810962996	#REF!

AmountUSD	Qualifier-Bucket-tenor	HVR	Weight (RW)	alpha	volatility	Weight (VRW)	HVR*Vol*Sk (VR)	HVR*Vol*Weight*Sk*CR
-2,000,000	ISIN:AU001159751155-2-1y	0.60	33.0	2.33	72.43	0.45	-86916642.61	-39112489.17
-1,000,000	ISIN:AU003186678890-2-2y	0.60	33.0	2.33	72.43	0.45	-43458321.3	-19556244.59

c) Calculate K for each bucket.

ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Equity	1	:AT016188495495-1	ISIN:AT016188495495-1-3m	17,778,404	17,778,404	100%	1.00	1.00	1.00	3.16072E+14
									K-Bucket 1	17778404.17

ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Equity	5	:AU002189533177-	ISIN:AU002189533177-5-3y	231,119,254	231,119,254	100%	1.00	1.00	1.00	5.34161E+16
									K-Bucket 5	231119254.2

ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Equity	Residual	770459100599-Resid	:GB770459100599-Residual	11,852,269	11,852,269	100%	1.00	1.00	1.00	1.40476E+14
									K-Bucket Residual	11852269.45

d) Calculate S for each currency and Vega Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Equity	1	17778404.17	3.16072E+14	17778404.17	17778404.17
Equity	5	231119254.2	5.34161E+16	231119254.2	231119254.2

Bucket		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
1	1	17778404.17	17778404.17	1	1	100%	1.00	0
1	5	17778404.17	231119254.2	1	1	14%	1.00	5.7525E+14
5	1	231119254.2	17778404.17	1	1	14%	1.00	5.7525E+14
5	5	231119254.2	231119254.2	1	1	100%	1.00	0
							SUM	1.1505E+15
							SUM of K^2	5.37322E+16
							K- Bucket Residual	11852269.45
							Vega Margin	246122801.4

Equity vega margin in IM output file can be found in column Risk_EQUITYVOL.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_EQUITY	RISK_EQUITYVOL	RISK_EQUITYCURVATURE	RISK_EQIM
ISDA-C429	USD	3E+08	Receive	All	RatesFX				
ISDA-C429	USD	3E+08	Receive	All	Credit				
ISDA-C429	USD	3E+08	Receive	All	Equity		246122801.4	53453275.21	299576076.6
ISDA-C429	USD	3E+08	Receive	All	Commodity				

Commodity Vega

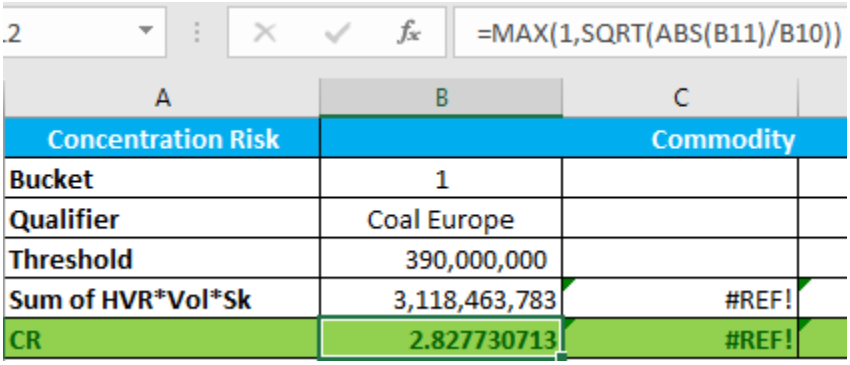
Here is an example of commodity vega margin calculation following Vega Margin Step by Step Formula.

a) Calculate **aggregated sensitivities.**

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000
Risk_CommodityVol	Coal Europe	1	2w		4,000,000	USD	4,000,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_CommodityVol	Coal Europe	1	2w		40,000,000	USD	=SUM(K17:K26)

e) Calculate HVR and **volatilities σ_{kj}, concentration risk factor** and **weighted sensitivities**. Concentration risk factor is calculated for each qualifier in same bucket.



	A	B	C
	Concentration Risk		Commodity
	Bucket	1	
	Qualifier	Coal Europe	
	Threshold	390,000,000	
	Sum of HVR*Vol*Sk	3,118,463,783	#REF!
	CR	2.827730713	#REF!

AmountUSD	Qualifier-Bucket-tenor	HVR	Weight (RW)	alpha	volatility	Weight (VRW)	HVR*Vol*Sk (VR)	HVR*Vol*Weight*Sk*CR
-32,000,000	Crude oil Americas-2-6m	0.74	29.0	2.33	63.65	0.55	-1507257495	-828991622.4
7,000,000	NA Power ERCOT-8-5y	0.74	52.0	2.33	114.13	0.55	591208758.9	325164817.4

b) Calculate K for each bucket.

ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Commodity	1	Coal Americas-1-1m	Coal Americas-1-1m	128,636,631	128,636,631	100%	1.00	1.00	1.00	1.65474E+16
									K-Bucket 1	128636631.1
ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Commodity	10	Freight Dry-10-10y	Freight Dry-10-10y	56,278,526	56,278,526	100%	1.00	1.00	1.00	3.16727E+15
									K-Bucket 10	56278526.09
ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	CR_1	CR_2	Adjustment factor	Production
Commodity	16	Ethanol-16-5y	Ethanol-16-5y	36,447,045	36,447,045	100%	1.00	1.00	1.00	1.32839E+15
									K-Bucket 16	36447045.47

c) Calculate S for each currency and Vega Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Commodity	1	128636631.1	1.65474E+16	128636631.1	128636631.1
Commodity	10	56278526.09	3.16727E+15	56278526.09	56278526.09
Commodity	16	36447045.47	1.32839E+15	36447045.47	36447045.47

Bucket		Sb_1	Sb_2	CR_1	CR_2	Correlation	g_12	Production
1	1	128636631.1	128636631.1	1	1	100%	1.00	0
1	10	128636631.1	56278526.09	1	1	14%	1.00	1.01353E+15
1	16	128636631.1	36447045.47	1	1	0%	1.00	0
10	1	56278526.09	128636631.1	1	1	14%	1.00	1.01353E+15
10	10	56278526.09	56278526.09	1	1	100%	1.00	0
10	16	56278526.09	36447045.47	1	1	0%	1.00	0
16	1	36447045.47	128636631.1	1	1	0%	1.00	0
16	10	36447045.47	56278526.09	1	1	0%	1.00	0
16	16	36447045.47	36447045.47	1	1	100%	1.00	0
							SUM	2.02705E+15
							SUM of K^2	2.1043E+16
							Vega Margin	151888435.6

Commodity vega margin in IM output file can be found in column Risk_COMMODITYVOL.

Portfol	Curren	Total Ir	IM_DIR	REGUL	Produc	RISK_COMMODITY	RISK_COMMODITYVOL	RISK_COMMODITYCURVATURE	RISK_COMMODITYIM
ISDA-C46	USD	6.35E+08	Receive	All	RatesFX				
ISDA-C46	USD	6.35E+08	Receive	All	Credit				
ISDA-C46	USD	6.35E+08	Receive	All	Equity				
ISDA-C46	USD	6.35E+08	Receive	All	Commodity		151888435.6	483249151.8	635137587.4

2.2.3 Curvature Margin

Curvature margin for **Interest Rate** is calculated based on risk types Risk_IRVol and Risk_InflationVol.

Curvature margin for **FX** is calculated based on risk type Risk_FXVol.

Curvature margin for **Credit Qualifying** is calculated based on risk type Risk_CreditVol.

Curvature margin for **Credit Non-Qualifying** is calculated based on risk type Risk_CreditVolNonQ.

Curvature margin for **Equity** is calculated based on risk type Risk_EquityVol.

Curvature margin for **Commodity** is calculated based on risk type Risk_CommodityVol.

2.2.3.1 Curvature Margin Step by Step Formula

The following is step by step approach of Curvature Margin calculation.

a) Calculate curvature sensitivities based on sensitivities VR_{ik} using the formula:

$$CVR_{ik} = \sum_j SF(t_{kj})\sigma_{kj}\frac{\partial V_i}{\partial \sigma}$$

where σ_{kj} and $\partial V_i/\partial\sigma$ are the volatility and vega defined in vega margin calculation. t_{kj} is the expiry time (in calendar days) from the valuation date until the expiry date of the standard option corresponding to this volatility and vega. $SF(t)$ is the value of scaling function obtained from the linkage between vega and gamma for vanilla options.

$$SF(t) = 0.5\min\left(1, \frac{14\ days}{t\ days}\right)$$

Here tenors are converted to calendar days using the convention that '12m' equals 365 calendar days. For example, 1m= 365/12 days and 5y=365*5 days.

Expiry	2w	1m	3m	6m	1y	2y	3y	5y	10y	15y	20y	30y
SF	50%	23.01%	7.67%	3.84%	1.92%	0.96%	0.64%	0.38%	0.19%	0.13%	0.1%	0.06%

b) Calculate **aggregated** curvature sensitivities CVR_{ik} with same risk type, qualifier, bucket, label1 and label2 for each product class and margin account. Note that the curvature for equity bucket 12 (volatility indexes) shall be taken to be zero.

c) Calculate K , which is the weighted sensitivities being aggregated within each bucket b.

$$K_b = \sqrt{\sum_k CVR_k^2 + \sum_k \sum_{l\neq k} \rho_{kl}^2 CVR_{b,k} CVR_{b,l}}$$

where ρ_{kl} is the correlation applicable to each risk class.

d) Calculate θ and λ cross non-residual buckets and residual bucket for each risk class.

For non-residual buckets:

$$\theta = min\left(\frac{\sum_{b,k} CVR_{b,k}}{\sum_{b,k} |CVR_{b,k}|}, 0\right)$$

$$\lambda = (\Phi^{-1}(99.5\%)^2 - 1)(1+\theta) - \theta$$

Where the sums are taken over all the non-residual buckets for each risk class, and $\Phi^{-1}(99.5\%)$ is the 99.5th percentile of the standard normal distribution.

For residual bucket:

$$\theta_{residual} = min\left(\frac{\sum_k CVR_{residual,k}}{\sum_k |CVR_{residual,k}|}, 0\right)$$
$$\lambda_{residual} = (\Phi^{-1}(99.5\%)^2 - 1)(1 + \theta_{residual}) - \theta_{residual}$$

e) Calculate Curvature Margin for within each risk class.

For non-residual buckets:

$$CurvatureMargin_{non-red} = max\left(\sum_{b,k} CVR_{b,k} + \lambda\sqrt{\sum_b K_b^2 + \sum_b \sum_{b \neq c} \gamma_{bc}^2 S_b S_c}, 0\right)$$

where

$$S_b = max\left(min\left(\sum_k CVR_{b,k}, K_b\right), -K_b\right)$$

For residual bucket:

$$CurvatureMargin_{residual} = max\left(\sum_k CVR_{residual,k} + \lambda_{residual} K_{residual}, 0\right)$$

and γ_{bc} is the correlation parameters for each risk class.

For Credit, FX, Equity and Commodity risk class,

$$CurvatureMargin = CurvatureMargin_{non-red} + CurvatureMargin_{residual}$$

For Interest rate risk class,

$$CurvatureMargin = HVR_{IR}^{-2}(CurvatureMargin_{non-red} + CurvatureMargin_{residual})$$

where HVR_{IR} is the historical volatility ratio for the interest rate risk class.

2.2.3.2 Curvature Margin Static Data

The static data used to calculate curvature margin is the same as static data of vega margin. See Vega Margin Static Data.

2.2.3.3 Curvature Margin Examples

Interest Rate Curvature

Here is an example of interest rate curvature margin calculation following Curvature Margin Step by Step Formula.

a) Calculate **curvature sensitivities** based on scaling factors and aggregated Risk_IRVol.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	Tenor	ScalingFactor (SF)	Risk_IRCurvature	ABS(Risk_IRCurvature)
Risk_IRVol	EUR		3y		50,000,000	USD	50,000,000	Risk_IRVol-3y	0.006392694	=K58*M58	319634.7032
Risk_IRVol	EUR		2y		-100,000,000	USD	-100,000,000	Risk_IRVol-2y	0.009589041	-958904.1096	958904.1096

b) Calculate K for each currency. Note that square of correlation is used.

ProductClass	Currency	Tenor Sk	Tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
RatesFX	EUR	Risk_IRVol-3y	Risk_IRVol-3y	319,635	319,635	100%	1.00	1.02166E+11
RatesFX	EUR	Risk_IRVol-3y	Risk_IRVol-2y	319,635	-958,904	96%	0.92	=E66*F66*H66
RatesFX	EUR	Risk_IRVol-2y	Risk_IRVol-3y	-958,904	319,635	96%	0.92	-2.8247E+11
RatesFX	EUR	Risk_IRVol-2y	Risk_IRVol-2y	-958,904	-958,904	100%	1.00	9.19497E+11
							K-EUR	675813.8959

c) Calculate θ and λ cross currencies.

	USD	JPY	CAD	Across the currency
Σbk CVR bk =	447488.5845	191780.8219	319634.7032	958904.1096
Σbk |CVR bk |=	447488.5845	191780.8219	319634.7032	958904.1096
θ =	0			
99.5th percentile of normal	2.575829304			
λ =	5.634896601			
γ =	32%			
ScalingFactor HVR^(-2) =	4.53			

d) Calculate S for each currency and Curvature Margin. Scaling factor HVR^{-2} is applied to curvature margin at final step for interest rate risk class.

Calculation of Sb factor

ProductClass	Currency	k	k^2	Sum of WSk	Sb
RatesFX	USD	447488.5845	2.00246E+11	447488.5845	447488.5845
RatesFX	JPY	191780.8219	36779883655	191780.8219	191780.8219
RatesFX	CAD	319634.7032	1.02166E+11	319634.7032	319634.7032

RatesFX		Sb_1	Sb_2	Correlation	Correlation^2	Production
USD	USD	447488.5845	447488.5845	100%	100%	0
USD	JPY	447488.5845	191780.8219	32%	10%	8787940201
USD	CAD	447488.5845	319634.7032	32%	10%	14646567002
JPY	USD	191780.8219	447488.5845	32%	10%	8787940201
JPY	JPY	191780.8219	191780.8219	100%	100%	0
JPY	CAD	191780.8219	319634.7032	32%	10%	6277100144
CAD	USD	319634.7032	447488.5845	32%	10%	14646567002
CAD	JPY	319634.7032	191780.8219	32%	10%	6277100144
CAD	CAD	319634.7032	319634.7032	100%	100%	0
					SUM	59423214695
					SUM of K^2	3.39192E+11
					Curvature Margin before Scaling facto	4516552.541
					Curvature Margin after Scaling factor	20446140.97

Interest Rate curvature margin in IM output file can be found in column Risk_IRCURVATURE.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_F	RISK_F	RISK_F	RISK_F	RISK_IR	RISK_IRCURVATURE	RISK_IRVOL	RISK_IRIM
ISDA-C334	USD	2.29E+08	Receive	All	RatesFX	229493240.9						20446140.97	209047100	229493240.9
ISDA-C334	USD	2.29E+08	Receive	All	Credit	0								
ISDA-C334	USD	2.29E+08	Receive	All	Equity	0								
ISDA-C334	USD	2.29E+08	Receive	All	Commodi	0								

FX Curvature

Here is an example of FX curvature margin calculation following Curvature Margin Step by Step Formula.

a) Calculate **curvature sensitivities** based on scaling factors, volatilities σ_{kj} and aggregated Risk_FXVol. Unlike FX vega calculation, the aggregation of Risk_FXVol should consider different tenors.

RiskType	Qualifier	Label1	Amount	AmountCurrency	AmountUSD	Qualifier-tenor	ScalingFactor (SF)	Weight (RW)	alpha	volatility	CreditCurvature	ABS(CreditCurvature)
Risk_FXVol	BRLUSD	2y	80,000,000	USD	80,000,000	BRLUSD-2y	0.009589041	14.7	2.33	32.26	=K56*M56*P56	24750857.96
Risk_FXVol	EURQAR	1m	-20,000,000	USD	-20,000,000	EURQAR-1m	0.230136986	7.4	2.33	16.24	-74757693.43	74757693.43

b) Calculate K for each currency pair. Note that square of correlation is used.

ProductClass	Qualifier	Qualifier-tenor Sk	Qualifier-tenor Sl	Wsk	Correlation	Correlation^2	Production
RatesFX	BRLUSD	BRLUSD-2y	BRLUSD-2y	24,750,858	100%	1.00	6.12605E+14
						K-USDGBP	24750857.96

ProductClass	Qualifier	Qualifier-tenor Sk	Qualifier-tenor Sl	Wsk	Correlation	Correlation^2	Production
RatesFX	EURQAR	EURQAR-1m	EURQAR-1m	-74,757,693	100%	1.00	5.58871E+15
						K-EURQAR	74757693.43

c) Calculate θ and λ cross currency pairs.

	BRLUSD	EURQAR	Across the currency
Σbk CVR bk =	24750857.96	-74757693.43	-50006835.47
Σbk |CVR bk |=	24750857.96	74757693.43	99508551.4
θ =	-0.502538071		
99.5th percentile of norm	2.575829304		
λ =	3.305684604		

d) Calculate S for each currency pair and Curvature Margin.

Calculation of Sb factor

ProductClass	Qualifier	k	k^2	Sum of WSk	Sb
RatesFX	BRLUSD	24750857.96	6.12605E+14	24750857.96	24750857.96
RatesFX	EURQAR	74757693.43	5.58871E+15	-74757693.43	-74757693.43

Qualifier		Sb_1	Sb_2	Correlation	Correlation^2	Production
BRLUSD	BRLUSD	24750857.96	24750857.96	100%	100%	0
BRLUSD	EURQAR	24750857.96	-74757693.43	50%	25%	-4.62579E+14
EURQAR	BRLUSD	-74757693.43	24750857.96	50%	25%	-4.62579E+14
EURQAR	EURQAR	-74757693.43	-74757693.43	100%	100%	0
					SUM	-9.25159E+14
					SUM of K^2	6.20132E+15
					Curvature Margin	190108755.1

FX curvature margin in IM output file can be found in column Risk_FXCURVATURE.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_FX	RISK_FXVOL	RISK_FXCURVATURE	RISK_FXIM
ISDA-C35€	USD	8.75E+08	Receive	All	RatesFX	875124274.8		685015519.7	190108755.1	875124274.8
ISDA-C35€	USD	8.75E+08	Receive	All	Credit	0				
ISDA-C35€	USD	8.75E+08	Receive	All	Equity	0				
ISDA-C35€	USD	8.75E+08	Receive	All	Commodi	0				

Credit Qualifying Curvature

Here is an example of credit qualifying curvature margin calculation following Curvature Margin Step by Step Formula.

a) Calculate **curvature sensitivities** based on scaling factors and aggregated Risk_CreditVol.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	ScalingFactor (SF)	CreditCurvature	ABS(CreditCurvature)
Risk_CreditVol	ISIN:US1850531850	1	1y	USD	120,000,000	USD	120,000,000	ISIN:US1850531850-1y-USD	0.019178082	=K60*M60	2301369.863
Risk_CreditVol	ISIN:CN0068511222	2	2y	CNY	-40,000,000	USD	-40,000,000	ISIN:CN0068511222-2y-CNY	0.009589041	-383561.6438	383561.6438
Risk_CreditVol	ISIN:CA2108230001	Residual	1y	USD	10,000,000	USD	10,000,000	ISIN:CA2108230001-1y-USD	0.019178082	191780.8219	191780.8219

b) Calculate K for each bucket. Note that square of correlation is used.

ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Credit	2	ISIN:CN0068511222-1y-CNY	ISIN:CN0068511222-1y-CNY	15,342,466	15,342,466	100%	1.00	2.35391E+14
Credit	2	ISIN:CN0068511222-1y-CNY	ISIN:CN0068511222-2y-CNY	15,342,466	-1,534,247	93%	0.86	-2.0359E+13
Credit	2	ISIN:CN0068511222-2y-CNY	ISIN:CN0068511222-1y-CNY	-1,534,247	15,342,466	93%	0.86	-2.0359E+13
Credit	2	ISIN:CN0068511222-2y-CNY	ISIN:CN0068511222-2y-CNY	-1,534,247	-1,534,247	100%	1.00	2.35391E+12
							K-Bucket 2	14036637.37

c) Calculate θ and λ cross non-residual buckets and for residual bucket.

	Bucket 1	Bucket 2	Across the Buckets
Σbk CVR bk =	2301369.863	-383561.6438	1917808.219
Σbk |CVR bk |=	2301369.863	383561.6438	2684931.507
θ =	0		
99.5th percentile of norm	2.575829304		
λ =	5.634896601		

	Bucket Residual	Across the Buckets
Σbk CVR bk =	191780.8219	191780.8219
Σbk |CVR bk |=	191780.8219	191780.8219
θ =	0	
99.5th percentile of norm	2.575829304	
λ =	5.634896601	

d) Calculate S for each non-residual buckets and Curvature Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Credit	1	2301369.863	5.2963E+12	2301369.863	2301369.863
Credit	2	383561.6438	1.4712E+11	-383561.6438	-383561.6438

Bucket		Sb_1	Sb_2	Correlation	Correlation^2	Production
1	1	2301369.863	2301369.863	100%	100%	0
1	2	2301369.863	-383561.6438	38%	14%	-1.27464E+11
2	1	-383561.6438	2301369.863	38%	14%	-1.27464E+11
2	2	-383561.6438	-383561.6438	100%	100%	0
					SUM	-2.54929E+11
					SUM of K^2	5.44342E+12
				Curvature Margin NonResidual		14753125.62
				Curvature Margin Residual		1272445.923
				Curvature Margin		16025571.55

Credit Qualifying curvature margin in IM output file can be found in column Risk_CREDITCURVATURE.

Portfol	Curren	Total In	IM_DIR	REGULA	Produc	RISK_IM	RISK_CREDITQ	RISK_CREDITVOL	RISK_CREDITCURVATURE	RISK_BASECORR	RISK_CRIM
ISDA-C38(	USD	1.08E+08	Receive	All	RatesFX	0					
ISDA-C38(	USD	1.08E+08	Receive	All	Credit	108091631		92066059.46	16025571.55		108091631
ISDA-C38(	USD	1.08E+08	Receive	All	Equity	0					
ISDA-C38(	USD	1.08E+08	Receive	All	Commodi	0					

Credit Non- Qualifying Curvature

Here is an example of credit non-qualifying curvature margin calculation following Curvature Margin Step by Step Formula.

a) Calculate **curvature sensitivities** based on scaling factors and aggregated Risk_CreditVolNonQ.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	ScalingFactor (SF)	CreditCurvature	ABS(CreditCurvature)
Risk_CreditVolNonQ	US.IG	1	1y	CMBX	30,000,000	USD	30,000,000	US.IG-1y-CMBX	0.019178082	=K58*M58	575342.4658
Risk_CreditVolNonQ	US.IG	1	2y	CMBX	-20,000,000	USD	-20,000,000	US.IG-2y-CMBX	0.009589041	-191780.8219	191780.8219
Risk_CreditVolNonQ	BR.HY	Residual	1y	CMBX	85,000,000	USD	85,000,000	BR.HY-1y-CMBX	0.019178082	1630136.986	1630136.986

b) Calculate K for each bucket. Note that square of correlation is used.

ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Credit	1	US.IG-1y-CMBX	US.IG-1y-CMBX	575,342	575,342	100%	1.00	3.31019E+11
Credit	1	US.IG-1y-CMBX	US.IG-2y-CMBX	575,342	-191,781	83%	0.69	-76012985551
Credit	1	US.IG-2y-CMBX	US.IG-1y-CMBX	-191,781	575,342	83%	0.69	-76012985551
Credit	1	US.IG-2y-CMBX	US.IG-2y-CMBX	-191,781	-191,781	100%	1.00	36779883655
							K-Bucket 1	464513.5794
ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Credit	Residual	BR.HY-1y-CMBX	BR.HY-1y-CMBX	1,630,137	1,630,137	100%	1.00	2.65735E+12
							K-Bucket Residual	1630136.986

c) Calculate θ and λ cross non-residual buckets and for residual bucket.

	Bucket 1	Across the Buckets
Σbk CVR bk =	383561.6438	383561.6438
Σbk |CVR bk |=	767123.2877	767123.2877
θ =	0	
99.5th percentile of norm	2.575829304	
λ =	5.634896601	

	Bucket Residual	Across the Buckets
Σbk CVR bk =	1630136.986	1630136.986
Σbk |CVR bk |=	1630136.986	1630136.986
θ =	0	
99.5th percentile of norm	2.575829304	
λ =	5.634896601	

d) Calculate S for each non-residual buckets and Curvature Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Credit	1	464513.5794	2.15773E+11	383561.6438	383561.6438

Bucket		Sb_1	Sb_2	Correlation	Correlation^2	Production
1	1	383561.6438	383561.6438	100%	100%	0
					SUM	0
					SUM of K^2	2.15773E+11
					Curvature Margin NonResidual	3001047.634
					Curvature Margin Residual	10815790.35
					Curvature Margin	13816837.98

Credit Qualifying curvature margin in IM output file can be found in column Risk_CREDITNONQCURVATURE.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_IM	RISK_CREDITNONQ	RISK_CREDITVOLNONQ	RISK_CREDITNONQCURVATURE	RISK_CRNQIM
ISDA-C40(	USD	98253624	Receive	All	RatesFX	0				
ISDA-C40(	USD	98253624	Receive	All	Credit	98253623.69		84436785.71	13816837.98	98253623.69
ISDA-C40(	USD	98253624	Receive	All	Equity	0				
ISDA-C40(	USD	98253624	Receive	All	Commodi	0				

Equity Curvature

Here is an example of equity curvature margin calculation following Curvature Margin Step by Step Formula.

a) Calculate **curvature sensitivities** based on scaling factors and aggregated Risk_EquityVol.

RiskType	Qualifier	Bucket	Label1	AmountUSD	Qualifier-Bucket-tenor	ScalingFactor (SF)	Weight (RW)	alpha	volatility	CreditCurvature	ABS(CreditCurvature)
Risk_EquityVol	ISIN:AT016188495495	1	3m	1,000,000	ISIN:AT016188495495-1-3m	0.076712329	30.0	2.33	65.85	=K61*M61*P61	5051195.502
Risk_EquityVol	ISIN:AU002189533177	5	3y	15,000,000	ISIN:AU002189533177-5-3y	0.006392694	26.0	2.33	57.07	5472128.461	5472128.461
Risk_EquityVol	ISIN:GB770459100599	Residual	10y	400,000	ISIN:GB770459100599-Residual	0.001917808	50.0	2.33	109.74	84186.59171	84186.59171

b) Calculate K for each bucket. Note that square of correlation is used.

ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Equity	1	:AT016188495495-1	ISIN:AT016188495495-1-3m	5,051,196	5,051,196	100%	1.00	2.55146E+13
							K-Bucket 1	5051195.502
ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Equity	5	:AU002189533177-5	ISIN:AU002189533177-5-3y	5,472,128	5,472,128	100%	1.00	2.99442E+13
							K-Bucket 5	5472128.461
ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Equity	Residual	770459100599-Resid	GB770459100599-Residual	84,187	84,187	100%	1.00	7087382223
							K-Bucket Residual	84186.59171

c) Calculate θ and λ cross non-residual buckets and for residual bucket.

	Bucket 1	Bucket 5	Across the Buckets
Σbk CVR bk =	5051195.502	5472128.461	10523323.96
Σbk |CVR bk |=	5051195.502	5472128.461	10523323.96
θ =	0		
99.5th percentile of norm	2.575829304		
λ =	5.634896601		

	Bucket Residual	Across the Buckets
Σbk CVR bk =	84186.59171	84186.59171
Σbk |CVR bk |=	84186.59171	84186.59171
θ =	0	
99.5th percentile of norm	2.575829304	
λ =	5.634896601	

d) Calculate S for each non-residual buckets and Curvature Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Equity	1	5051195.502	2.55146E+13	5051195.502	5051195.502
Equity	5	5472128.461	2.99442E+13	5472128.461	5472128.461

Bucket		Sb_1	Sb_2	Correlation	Correlation^2	Production
1	1	5051195.502	5051195.502	100%	100%	0
1	5	5051195.502	5472128.461	14%	2%	5.41759E+11
5	1	5472128.461	5051195.502	14%	2%	5.41759E+11
5	5	5472128.461	5472128.461	100%	100%	0
					SUM	1.08352E+12
					SUM of K^2	5.54588E+13
					Curvature Margin NonResidual	52894705.88
					Curvature Margin Residual	558569.3312
					Curvature Margin	53453275.21

Equity curvature margin in IM output file can be found in column Risk_EQUITYCURVATURE.

Portfol	Curren	Total In	IM_DIR	REGULA	Produc	RISK_EQUITY	RISK_EQUITYVOL	RISK_EQUITYCURVATURE	RISK_EQIM
ISDA-C425	USD	3E+08	Receive	All	RatesFX				
ISDA-C425	USD	3E+08	Receive	All	Credit				
ISDA-C425	USD	3E+08	Receive	All	Equity		246122801.4	53453275.21	299576076.6
ISDA-C425	USD	3E+08	Receive	All	Commodity				

Commodity Curvature

Here is an example of commodity curvature margin calculation following Curvature Margin Step by Step Formula.

a) Calculate **curvature sensitivities** based on scaling factors and aggregated Risk_CommodityVol.

RiskType	Qualifier	Bucket	Label1	AmountUSD	Qualifier-Bucket-tenor	ScalingFactor (SF)	Weight (RW)	alpha	volatility	CreditCurvature	ABS(CreditCurvature)
Risk_CommodityVol	Coal Americas	1	1m	3,000,000	Coal Americas-1-1m	0.230136986	48.0	2.33	105.35	=K65*M65*P65	72737215.23
Risk_CommodityVol	Freight Dry	10	10y	1,000,000	Freight Dry-10-10y	0.001917808	63.0	2.33	138.28	265187.7639	265187.7639
Risk_CommodityVol	Ethanol	16	5y	600,000	Ethanol-16-5y	0.003835616	68.0	2.33	149.25	343481.2942	343481.2942

b) Calculate K for each bucket. Note that square of correlation is used.

ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Commodity	1	Coal Americas-1-1m	Coal Americas-1-1m	72,737,215	72,737,215	100%	1.00	5.2907E+15
							K-Bucket 2	72737215.23
ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Commodity	10	Freight Dry-10-10y	Freight Dry-10-10y	265,188	265,188	100%	1.00	70324550108
							K-Bucket 8	265187.7639
ProductClass	Bucket	alifier-Bucket-teno	Qualifier-Bucket-tenor Sl	Wsk	Wsl	Correlation	Correlation^2	Production
Commodity	16	Ethanol-16-5y	Ethanol-16-5y	343,481	343,481	100%	1.00	1.17979E+11
							K-Bucket 8	343481.2942

c) Calculate θ and λ cross buckets.

	Bucket 1	Bucket 10	Bucket 16	Across the Buckets
Σbk CVR bk =	72737215.23	265187.7639	343481.2942	73345884.29
Σbk |CVR bk |=	72737215.23	265187.7639	343481.2942	73345884.29
θ =	0			
99.5th percentile of norm	2.575829304			
λ =	5.634896601			

d) Calculate S for each bucket and Curvature Margin.

Calculation of Sb factor

ProductClass	Bucket	k	k^2	Sum of WSk	Sb
Commodity	1	72737215.23	5.2907E+15	72737215.23	72737215.23
Commodity	10	265187.7639	70324550108	265187.7639	265187.7639
Commodity	16	343481.2942	1.17979E+11	343481.2942	343481.2942

Bucket		Sb_1	Sb_2	Correlation	Correlation^2	Production
1	1	72737215.23	72737215.23	100%	100%	0
1	10	72737215.23	265187.7639	14%	2%	3.78065E+11
1	16	72737215.23	343481.2942	0%	0%	0
10	1	265187.7639	72737215.23	14%	2%	3.78065E+11
10	10	265187.7639	265187.7639	100%	100%	0
10	16	265187.7639	343481.2942	0%	0%	0
16	1	343481.2942	72737215.23	0%	0%	0
16	10	343481.2942	265187.7639	0%	0%	0
16	16	343481.2942	343481.2942	100%	100%	0
					SUM	7.5613E+11
					SUM of K^2	5.29089E+15
					Curvature Margin	483249151.8

Commodity curvature margin in IM output file can be found in column Risk_COMMODITYCURVATURE.

Portfol	Curren	Total Ir	IM_DIR	REGULA	Produc	RISK_COMMODITY	RISK_COMMODITYVOL	RISK_COMMODITYCURVATURE	RISK_COMMODITYIM
ISDA-C46	USD	6.35E+08	Receive	All	RatesFX				
ISDA-C46	USD	6.35E+08	Receive	All	Credit				
ISDA-C46	USD	6.35E+08	Receive	All	Equity				
ISDA-C46	USD	6.35E+08	Receive	All	Commodity		151888435.6	483249151.8	635137587.4

2.2.4 Base Correlation Margin

Base Correlation Margin is calculated based on risk type Risk_BaseCorr, and it's only applicable for credit qualifying risk class.

2.2.4.1 Base Correlation Margin Step by Step Formula

The following is step by step approach of delta margin calculation for non-interest rate class.

a) Calculate **aggregated sensitivities** S_k with same risk type, qualifier, bucket, label1 and label2 for each product class and margin account.

b) Calculate **weighted sensitivities** WS_k. More details are provided in Base Correlation Margin Static Data.

$$WS_k = RW_k S_k$$

Note that base correlation sensitivities are not included in concentration risk, and concentration risk of Risk_BaseCorr is 1.

c) Calculate BaseCorrMargin, which is the weighted sensitivities being aggregated within each bucket.

$$BaseCorrMargin = \sqrt{\sum_k WS_k^2 + \sum_k \sum_{l \neq k} \rho_{kl} WS_k WS_l}$$

where ρ_{kl} is the correlation parameters.

2.2.4.2 Base Correlation Margin Static Data

Base Correlation risk weight is 10 for all index families.

Correlation applying to Base Correlation cross different index families is 29%.

2.2.4.3 Base Correlation Margin Examples

Credit Base Correlation margin

Here is an example of Credit Base Correlation margin calculation following Base Correlation Margin Step by Step Formula.

a) Calculate aggregated sensitivities.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_BaseCorr	CDX IG				500,000	USD	500,000
Risk_BaseCorr	CDX IG				-200,000	USD	-200,000
Risk_BaseCorr	iTraxx Main				400,000	USD	400,000

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD
Risk_BaseCorr	CDX IG				300,000	USD	=SUM(K16:K17)
Risk_BaseCorr	iTraxx Main				400,000	USD	400,000

b) Calculate **concentration risk factor** and **weighted sensitivities**.

In case of base correlation sensitivities Risk_BaseCorr, concetration risk is 1.

RiskType	Qualifier	Bucket	Label1	Label2	Amount	AmountCurrency	AmountUSD	ISIN-tenor-ccy	Weight	Weight*Sk*CR
Risk_BaseCorr	CDX IG				300,000	USD	300,000	CDX IG--	10	3000000
Risk_BaseCorr	iTraxx Main				400,000	USD	400,000	iTraxx Main--	10	4000000

c) Calculate K for each bucket.

ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	Production
Credit		CDX IG--	CDX IG--	3,000,000	3,000,000	100%	9E+12
						K-CDX IG	3000000
ProductClass	Bucket	ISIN-tenor-ccy Sk	ISIN-tenor-ccy Sl	Wsk	Wsl	Correlation	Production
Credit		iTraxx Main--	iTraxx Main--	4,000,000	4,000,000	100%	1.6E+13
						K-iTraxx Main	4000000

d) Calculate S for each bucket and Base Correlation Margin.

ProductClass	ISIN-tenor-ccy	k	k^2	Sum of WSk	Sb
Credit	CDX IG--	3000000	9E+12	7000000	3000000
Credit	iTraxx Main--	4000000	1.6E+13	4000000	4000000

ISIN-tenor-ccy		Sb_1	Sb_2	correlation	Production
CDX IG--	CDX IG--	3000000	3000000	100%	0
CDX IG--	iTraxx Main--	3000000	4000000	29%	3.48E+12
iTraxx Main--	CDX IG--	4000000	3000000	29%	3.48E+12
iTraxx Main--	iTraxx Main--	4000000	4000000	100%	0
				SUM	6.96E+12
				SUM of K^2	2.5E+13
				BaseCorr Margin	5653317.61

Credit Base Correlation delta margin in IM output file can be found in column Risk_BASECORR.

Portfol	Curren	Total Ir	IM_DIR	REGUL	Produc	RISK_IM	RISK_CREDITQ	RISK_CREDITVOL	RISK_CREDITCURVATURE	RISK_BASECORR	RISK_CRIM
ISDA-C132	USD	5653318	Receive	All	RatesFX	0					
ISDA-C132	USD	5653318	Receive	All	Credit	5653317.61				5653317.61	5653317.61
ISDA-C132	USD	5653318	Receive	All	Equity	0					
ISDA-C132	USD	5653318	Receive	All	Commodi	0					

Additional Initial Margin

Once SIMM IM is calculated for each product class (RatesFX, Credit, Equity and Commodity), additional initial margin is calculated based on regulator parameters Param_AddOnFixedAmount, Param_AddOnNotionalFactor and Param_ProductClassMultiplier.

The formula for calculating additional initial margin is given as:

$$\begin{aligned} &Additional\ Initial\ Margin \\ &= AddOnIM + (MS_{RatesFX} - 1)SIMM_{RatesFX} + (MS_{Credit} - 1)SIMM_{Credit} + (MS_{Equity} - 1)SIMM_{Equity} \\ &+ (MS_{Commodity} - 1)SIMM_{Commodity} \end{aligned}$$

and

$$AddOnIM = AddOnFixed + \sum_{product\ p} AddOnFactor_p Notional_p$$

where

- $AddOnFixed$ is a fixed add-on amount. This is defined by Param_AddOnFixedAmount.

MARGIN_AGREEMENT_NAME	RISK_TYPE	AMOUNT	CURRENCY
ISDA-C481	Param_AddOnFixedAmount	30000000	USD

- $AddOnFactor_p$ is the add-on factor for each effected product p, expressed as percentage of the notional (e.g 5%). This is defined by Param_AddOnNotionalFactor. $Notional_p$ is the notional of the product. This is defined by trade level risk factor Notional with IM_MODEL SIMM.

  Here is an example of $AddOnNotionalFactor$ calculation.

TRADE_	UTI	PARTY_	CP_ID	MARGI	IM_MO	RISK_TYPE	PRODU	QUALIFIER	AMOUNT	CURRE	AMOUNT_USD
				ISDA-C481		Param_AddOnNotionalFactor		Product Alpha	12.5		
				ISDA-C481		Param_AddOnNotionalFactor		Product Bravo	25		
C481-1246		NOT-Cpty	CptyC	ISDA-C481	SIMM	Notional	RatesFX	Product Alpha	80000000	USD	80000000
C481-1248		NOT-Cpty	CptyC	ISDA-C481	SIMM	Notional	RatesFX	Product Bravo	100000000	USD	100000000
C481-1247		NOT-Cpty	CptyC	ISDA-C481	SIMM	Notional	RatesFX	Product Bravo	60000000	USD	60000000

RiskType	Qualifier	Amount	AmountCurrency	AmountUSD	NotioanlFactor	AddOnNotioanlFactor
Notional	Product Alpha	80,000,000.0	USD	80,000,000.0	12.5%	=K101*L101
Notional	Product Bravo	160,000,000.0	USD	160,000,000.0	25.0%	40,000,000.0
Notional	Product Charlie	40,000,000.0	USD	40,000,000.0	0.0	0.0
					AddOnFactorNotional	50,000,000

- $MS_{RatesFX}$, MS_{Credit}, MS_{Equity}, $MS_{Commodity}$ are the four multiplicative scales for the four product classes. They are defined by Param_ProductClassMultiplier. Their value is expected to be more than 1.0, with default and minimum value 1.
  Here is an example of product class add-on calculation.

MARGIN_AGREEMENT_NAME	RISK_TYPE	QUALIFIER	AMOUNT
ISDA-C481	Param_ProductClassMultiplier	Commodity	1.054
ISDA-C481	Param_ProductClassMultiplier	Credit	1.034
ISDA-C481	Param_ProductClassMultiplier	Equity	1.215
ISDA-C481	Param_ProductClassMultiplier	RatesFX	1.045

RiskType	Qualifier	Amount	AmountCurrency	AmountUSD	IM product class	MS
Param_ProductClassMultiplier	RatesFX	1.045		1.045	60372045795.40	=(K108-1)*L108
Param_ProductClassMultiplier	Credit	1.034		1.034	6305975760.27	214,403,175.8
Param_ProductClassMultiplier	Equity	1.215		1.215	22772698197.36	4,896,130,112.4
Param_ProductClassMultiplier	Commodity	1.054		1.054	58733120786.72	3,171,588,522.5
					AddOnFactorNotional	10,998,863,872

Additional IM is the sum of above three components, which can be found in column Additional IM in IM output file.

Portfol	Curren	Total In	IM_DIR	REGULA	IM SIMM	Additional IM	Product Class	RISK_IM
ISDA-C481	USD	1.59E+11	Receive	All	1.59263E+11	11078863872	RatesFX	60372045795
ISDA-C481	USD	1.59E+11	Receive	All			Credit	6305975760
ISDA-C481	USD	1.59E+11	Receive	All			Equity	22772698197
ISDA-C481	USD	1.59E+11	Receive	All			Commodity	58733120787

SCHEDULE Methodology

To provide a complete margin solution compliant with BCBS 261 (See https://www.bis.org/publ/bcbs261.pdf), Schedule-based margin methodology is implemented besides ISDA SIMM method.

SCHEDULE margin is calculated based on risk types NOTIONAL and PV for all trades subject to SCHEDULE model based on regulatory requirements. Schedule method is also referred to as GRID, as it's based on a percentage grid where each trade contributes to a gross initial margin.

The schedule IM is given by the formula:

$$SCHEDULE\ IM = (0.4 + 0.6 * NGR) * GIM$$

$$NGR = \begin{cases} \dfrac{max(A+B,0)}{A}, & A \neq 0 \\ 1, & A = 0 \end{cases}$$

$$GIM = \sum_i MarginRate_i * Notional_i$$

where

- NGR is net-to-gross ratio.
- A is the sum of positive NPVs, using risk_type PV with im_model SCHEDULE.
- B is the sum of negative NPVs, using risk_type PV with im_model SCHEDULE.
- GIM is the sum of Margin rate * Gross notional of all trades in margin account. Use risk_type Notional with im_model SCHEDULE. Margin rate is defined based on below table.

Product Class	Remain Maturity	Margin Rate (% of Notional)
Rates	0D -2Y	1
Rates	2Y -5Y	2
Rates	> 5Y	4
Credit	0D -2Y	2
Credit	2Y -5Y	5
Credit	> 5Y	10
FX	All	6
Equity	All	15
Commodity	All	15

Product Class	Remain Maturity	Margin Rate (% of Notional)
Other	All	15

Here is an example of schedule IM calculation.

Below are the given risk factors of schedule trades from various product classes.

TRADE_ID	PARTY_ID	CP_ID	ARGIN_AGREEMENT_NAM	IM_MODEL	RISK_TYPE	QUALIFIER	AMOUNT	CURRENCY	AMOUNT_USD	PRODUCT_CLASS	END_DATE
10001	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	CDS	1500000000	USD	1500000000	Credit	2030-12-20
10001	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	CDS	164217106.1	USD	164217106.1	Credit	2030-12-20
10002	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	Swap	100000000	USD	100000000	Rates	2024-10-20
10002	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	Swap	-79991.61525	USD	-79991.61525	Rates	2024-10-20
10003	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	Swap	100000000	USD	100000000	Rates	2026-05-10
10003	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	Swap	-453197.2226	USD	-453197.2226	Rates	2026-05-10
10004	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	CapFloor	1000000000	USD	1000000000	Rates	2030-05-13
10004	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	CapFloor	18203079.52	USD	18203079.52	Rates	2030-05-13
10005	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	Swaption	1000000	USD	1000000	Rates	2024-04-11
10005	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	Swaption	-512630.1677	USD	-512630.1677	Rates	2024-04-11
10006	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	SwapCrossCurrency	20000000	USD	20000000	Rates	2024-12-09
10006	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	SwapCrossCurrency	-6288.692155	USD	-6288.692155	Rates	2024-12-09
10007	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	FXNDF	240000000	USD	240000000	FX	2024-03-21
10007	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	FXNDF	-40103932.13	USD	-40103932.13	FX	2024-03-21
10008	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	EquityLinkedSwap	12000000	USD	12000000	Equity	2025-04-28
10008	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	EquityLinkedSwap	-39678.48769	USD	-39678.48769	Equity	2025-04-28
10009	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	Notional	FutureCommodity	10000000	USD	10000000	Commodity	2023-11-30
10009	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	FutureCommodity	-182000	USD	-182000	Commodity	2023-11-30

Step1: Calculate NGR (net-to-gross ratio) based on sum of positive PVs and negative PVs. NGR=1 when sum of positive PVs is zero.

NGR = max(A+B,0)/A. If A is zero, NGR=1	0.773173576
A = Sum of Positive NPV (for all trades in netting set)	182420185.60
B = Sum of Negative NPV (for all trades in netting set)	-41377718.31

TRADE_ID	PARTY_ID	CP_ID	ARGIN_AGREEMENT_NAM	IM_MODEL	RISK_TYPE	QUALIFIER	AMOUNT	CURRENCY	AMOUNT_USD	PRODUCT_CLASS	END_DATE
10007	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	FXNDF	-40103932.13	USD	-40103932.13	FX	2024-03-21
10005	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	Swaption	-512630.1677	USD	-512630.17	Rates	2024-04-11
10003	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	Swap	-453197.2226	USD	-453197.22	Rates	2026-05-10
10009	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	FutureCommodity	-182000	USD	-182000.00	Commodity	2023-11-30
10002	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	Swap	-79991.61525	USD	-79991.62	Rates	2024-10-20
10008	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	EquityLinkedSwap	-39678.48769	USD	-39678.49	Equity	2025-04-28
10006	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	SwapCrossCurrency	-6288.692155	USD	-6288.69	Rates	2024-12-09
10004	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	CapFloor	18203079.52	USD	18203079.52	Rates	2030-05-13
10001	CALYPSOSIMM	CP_1	CSA_SCHE	SCHEDULE	PV	CDS	164217106.1	USD	164217106.07	Credit	2030-12-20

Step2: Calculate GIM based on Margin Rate. Remain maturity is calculated based on trade end date and valuation date.

TRADE_ID	IM_MODEL	RISK_TYPE	QUALIFIER	AMOUNT_USD	PRODUCT_CLASS	END_DATE	Valuation_date	Remain Maturity	Margin Rate	GIM
10001	SCHEDULE	Notional	CDS	1500000000.00	Credit	2030-12-20	2023-10-30	> 5Y	10.00%	=J43*O43
10002	SCHEDULE	Notional	Swap	100000000.00	Rates	2024-10-20	2023-10-30	0D -2Y	1.00%	1000000
10003	SCHEDULE	Notional	Swap	100000000.00	Rates	2026-05-10	2023-10-30	2Y -5Y	2.00%	2000000
10004	SCHEDULE	Notional	CapFloor	1000000000.00	Rates	2030-05-13	2023-10-30	> 5Y	4.00%	40000000
10005	SCHEDULE	Notional	Swaption	1000000.00	Rates	2024-04-11	2023-10-30	0D -2Y	1.00%	10000
10006	SCHEDULE	Notional	SwapCrossCurrency	20000000.00	Rates	2024-12-09	2023-10-30	0D -2Y	1.00%	200000
10007	SCHEDULE	Notional	FXNDF	240000000.00	FX	2024-03-21	2023-10-30	0D -2Y	6.00%	14400000
10008	SCHEDULE	Notional	EquityLinkedSwap	12000000.00	Equity	2025-04-28	2023-10-30	0D -2Y	15.00%	1800000
10009	SCHEDULE	Notional	FutureCommodity	10000000.00	Commodity	2023-11-30	2023-10-30	0D -2Y	15.00%	1500000
									Sum GIM	210910000

Step3: Calculate SCHEDULE IM

IM= (0.4 + 0.6*NGR) *GIM = 182206023.4

IM Schedule, Positive NPV, Negative NPV, NGR and Gross Notional can be found in IM output file.

Portfol	Curren	Total In	IM_DIR	REGULA	IM Schedule	Positive NPV	Negative NPV	NGR	Gross Notional
CSA_SCHE	USD	1.82E+08	Receive	All	182206023.4	182420185.6	-41377718.32	0.773174	210910000
CSA_SCHE	USD	1.82E+08	Receive	All					
CSA_SCHE	USD	1.82E+08	Receive	All					
CSA_SCHE	USD	1.82E+08	Receive	All					

SIMM and SCHEDULE Full Validation Examples

Please refer to the spreadsheet SIMM and SCHDEULE IM Model Validation Examples.xlsx where it details the 65 step-by-step validation cases.

SIMM and SCHEDULE IM Model Validation Examples
This document details SIMM and SCHEDULE IM Model validation examples based on **ISDA 2.6** materials, including IM models and static data.
The examples are choosen from ISDA 2.6 Unit Tests (10-day) which are highlighed in yellow in tab 'Combinations (10-day)', and risk factor inputs can be found in tab 'Sensitivity Inputs'.
Below are the scenarios which has step-by-step IM calculation validation comparing to ISDA benchmark as well as Calypso Output file.
Rates Delta: C1,C31,C46,C47,C51,C57,C58,C66
FX Delta: C69,C72,C74,C78
Credit Delta: C107,C113,C117,C123,C132,C150,C158,C162
Equity Delta: C194,C198,C211,C215,C221
Commodity Delta: C257,C268,C284,C288
Rates Vega & Curvature: C299,C316,C319,C324,C327,C334
FX Vega & Curvature: C336,C347,C351,C353,C356,C357
Credit Vega & Curvature: C360,C368,C371,C376,C380,C382,C392,C397,C400
Equity Vega & Curvature: C402,C412,C416,C419,C422,C429,C430
Commodity Vega & Curvature: C433,C449,C460,C462,C466,C469
Add-Ons and Global: C481
SCHEDULE IM: SCHEDULE
Full Calypso IM results can be found in tab 'Calypso IM results'.