

# Basel Committee on Banking Supervision

CRE

Calculation of RWA for credit  
risk

CRE99

Application guidance

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framework.



BANK FOR INTERNATIONAL SETTLEMENTS



## Introduction

**99.1** The guidance set out in this chapter relates to the chapters of the credit risk standard ([CRE](#)). This chapter includes the following:

- (1) Illustrative risk weights calculated under the internal ratings-based (IRB) approach to credit risk ([CRE99.2](#) to [CRE99.3](#)).
- (2) Illustrative examples for recognition of dilution risk when applying the Securitisation Internal Ratings-Based Approach (SEC-IRBA) to securitisation exposures ([CRE99.4](#) to [CRE99.19](#)).
- (3) Illustrative examples of the application of the standardised approach to counterparty credit risk (SA-CCR) to sample portfolios ([CRE99.20](#) to [CRE99.97](#)).
- (4) Illustrative examples on the effect of margin agreements on the SA-CCR formulation ([CRE99.98](#) to [CRE99.115](#)).
- (5) Equity investments in funds: illustrative example of the calculation of risk-weighted assets (RWA) under the look-through approach (LTA) ([CRE99.116](#) to [CRE99.120](#)).
- (6) Equity investments in funds: illustrative example of the calculation of RWA under the mandate-based approach (MBA) ([CRE99.121](#) to [CRE99.127](#)).
- (7) Equity investments in funds: illustrative examples of the leverage adjustment ([CRE99.128](#) to [CRE99.133](#)).

## Illustrative risk weights calculated under the IRB approach to credit risk

**99.2** Table 1 provides illustrative risk weights calculated for four exposure types under the IRB approach to credit risk. Each set of risk weights for unexpected loss (UL) was produced using the appropriate risk-weight function of the risk-weight functions set out in [CRE31](#). The inputs used to calculate the illustrative risk weights include measures of the probability of default (PD), loss-given-default (LGD), and an assumed effective maturity (M) of 2.5 years, where applicable.

**99.3** A firm-size adjustment applies to exposures made to small or medium-sized entity borrowers (defined as corporate exposures where the reported sales for the consolidated group of which the firm is a part is less than €50 million). Accordingly, the firm size adjustment was made in determining the second set of risk weights provided in column two for corporate exposures given that the turnover of the firm receiving the exposure is assumed to be €5 million.

Illustrative IRB risk weights for UL

Table 1

Asset class	Corporate Exposures		Residential Mortgages		Other Retail Exposures		Qualifying Revolving Retail Exposures	
LGD:	45%	45%	45%	25%	45%	85%	45%	85%
Turnover (millions of €):	50	5						
Maturity:	2.5 years	2.5 Years						
PD:								
0.03%	14.44%	11.30%	4.15%	2.30%	4.45%	8.41%	0.98%	1.85%
0.05%	19.65%	15.39%	6.23%	3.46%	6.63%	12.52%	1.51%	2.86%
0.10%	29.65%	23.30%	10.69%	5.94%	11.16%	21.08%	2.71%	5.12%
0.25%	49.47%	39.01%	21.30%	11.83%	21.15%	39.96%	5.76%	10.88%
0.40%	62.72%	49.49%	29.94%	16.64%	28.42%	53.69%	8.41%	15.88%
0.50%	69.61%	54.91%	35.08%	19.49%	32.36%	61.13%	10.04%	18.97%
0.75%	82.78%	65.14%	46.46%	25.81%	40.10%	75.74%	13.80%	26.06%
1.00%	92.32%	72.40%	56.40%	31.33%	45.77%	86.46%	17.22%	32.53%
1.30%	100.95%	78.77%	67.00%	37.22%	50.80%	95.95%	21.02%	39.70%

1.50%	105.59%	82.11%	73.45%	40.80%	53.37%	100.81%	23.40%	44.19%
2.00%	114.86%	88.55%	87.94%	48.85%	57.99%	109.53%	28.92%	54.63%
2.50%	122.16%	93.43%	100.64%	55.91%	60.90%	115.03%	33.98%	64.18%
3.00%	128.44%	97.58%	111.99%	62.22%	62.79%	118.61%	38.66%	73.03%
4.00%	139.58%	105.04%	131.63%	73.13%	65.01%	122.80%	47.16%	89.08%
5.00%	149.86%	112.27%	148.22%	82.35%	66.42%	125.45%	54.75%	103.41%
6.00%	159.61%	119.48%	162.52%	90.29%	67.73%	127.94%	61.61%	116.37%
10.00%	193.09%	146.51%	204.41%	113.56%	75.54%	142.69%	83.89%	158.47%
15.00%	221.54%	171.91%	235.72%	130.96%	88.60%	167.36%	103.89%	196.23%
20.00%	238.23%	188.42%	253.12%	140.62%	100.28%	189.41%	117.99%	222.86%

## Illustrative examples for recognition of dilution risk when applying SEC-IRBA to securitisation exposures

**99.4** The following examples are provided to illustrate the recognition of dilution risk according to [CRE44.12](#) and [CRE44.13](#). The first example in [CRE99.5](#) to [CRE99.8](#) assumes a common waterfall for default and dilution losses. The second example in [CRE99.9](#) to [CRE99.19](#) assumes a non-common waterfall for default and dilution losses.

**99.5** Common waterfall for default and dilution losses: in the first example, it is assumed that losses resulting from either defaults or dilution within the securitised pool will be subject to a common waterfall, ie the loss-allocation process does not distinguish between different sources of losses within the pool.

**99.6** The pool is characterised as follows. For the sake of simplicity, it is assumed that all exposures have the same size, same PD, same LGD and same maturity.

(1) Pool of €1,000,000 of corporate receivables

(2)  $N = 100$

(3)  $M = 2.5 \text{ years}^1$

(4)  $PD_{\text{Dilution}} = 0.55\%$

(5)  $LGD_{\text{Dilution}} = 100\%$

(6)  $PD_{\text{Default}} = 0.95\%$

(7)  $LGD_{\text{Default}} = 45\%$

### Footnotes

<sup>1</sup> For the sake of simplicity, the possibility described in [CRE34.8](#) to set  $M_{\text{Dilution}} = 1$  is not used in this example.

**99.7** The capital structure is characterised as follows:

(1) Tranche A is a senior note of €700,000

(2) Tranche B is a second-loss guarantee of €250,000

(3) Tranche C is a purchase discount of €50,000

- (4) Final legal maturity of transaction / all tranches = 2.875 years, ie  $M_T = 2.5$  years<sup>2</sup>

*Footnotes*

<sup>2</sup> *The rounding of the maturity calculation is shown for example purposes.*

**99.8** RWA calculation:

- (1) Step 1: calculate  $K_{IRB,Dilution}$  and  $K_{IRB,Default}$  for the underlying portfolio:

(a)  $K_{IRB,Dilution} = \frac{€1,000,000 \times (161.44\% \times 8\% \times 1.06 + 0.55\% \times 100\%)}{€1,000,000} = 14.24\%$

(b)  $K_{IRB,Default} = \frac{(€1,000,000 - €136,900)^3 \times (90.62\% \times 8\% \times 1.06 + 0.95\% \times 45\%)}{€1,000,000} = 7\%$

- (2) Step 2: calculate  $K_{IRB,Pool} = K_{IRB,Dilution} + K_{IRB,Default} = 14.24\% + 7\% = 21.24\%$

(3) Step 3: apply the SEC-IRBA to the three tranches

(a) Pool parameters:

(i)  $N = 100$

(ii) 
$$\text{LGD}_{\text{Pool}} = (\text{LGD}_{\text{Default}} \times K_{\text{IRB,Default}} + \text{LGD}_{\text{Dilution}} \times K_{\text{IRB,Dilution}}) / K_{\text{IRB,Pool}}$$

$$= (45\% \times 7\% + 100\% \times 14.24\%) / 21.24\% = 81.87\%$$

(b) Tranche parameters:

(i)  $M_T = 2.5$  years

(ii) Attachment and detachment points shown in Table 2

Attachment and detachment points for each tranche		Table 2
	Attachment point	Detachment point
Tranche A	30%	100%
Tranche B	5%	30%
Tranche C	0%	5%

(4) Resulting risk-weighted exposure amounts shown in Table 3

Risk-weighted exposure amounts for each tranche		Table 3
	SEC-IRBA risk weight	RWA
Tranche A	28.78%	€201,460
Tranche B	1056.94%	€2,642,350
Tranche C	1250%	€625,000

*Footnotes*

<sup>3</sup>

*As described in [CRE34.5](#), when calculating the default risk of exposures with non-immaterial dilution risk "EAD will be calculated as the outstanding amount minus the capital requirement for dilution prior to credit risk mitigation".*



**99.9** Non-common waterfall for default and dilution losses: in the second example, it is assumed that the securitisation transaction does not have one common waterfall for losses due to defaults and dilutions, ie for the determination of the risk of a specific tranche it is not only relevant what losses might be realised within the pool but also if those losses are resulting from default or a dilution event.

**99.10** As the SEC-IRBA assumes that there is one common waterfall, it cannot be applied without adjustments. The following example illustrates one possible scenario and a possible adjustment specific to this scenario.

**99.11** While this example is meant as a guideline, a bank should nevertheless consult with its national supervisor as to how the capital calculation should be performed (see [CRE44.13](#)).

**99.12** The pool is characterised as in [CRE99.6](#).

**99.13** The capital structure is characterised as follows:

- (1) Tranche A is a senior note of €950,000
- (2) Tranche C is a purchase discount of €50,000
- (3) Tranches A and C will cover both default and dilution losses
- (4) In addition, the structure also contains a second-loss guarantee of €250,000 (Tranche B)<sup>4</sup> that covers only dilution losses exceeding a threshold of €50,000 up to maximum aggregated amount of €300,000, which leads to the following two waterfalls:
  - (a) Default waterfall
    - (i) Tranche A is a senior note of €950,000
    - (ii) Tranche C is a purchase discount of €50,000<sup>5</sup>
  - (b) Dilution waterfall
    - (i) Tranche A is a senior note of €700,000
    - (ii) Tranche B is a second-loss guarantee of €250,000
    - (iii) Tranche C is a purchase discount of €50,000<sup>6</sup>
- (5)  $M_T$  of all tranches is 2.5 years.

*Footnotes*

<sup>4</sup> For the sake of simplicity, it is assumed that the second loss guarantee is cash-collateralised.

<sup>5</sup> Subject to the condition that it is not already being used for realised dilution losses.

<sup>6</sup> Subject to the condition that it is not already being used for realised default losses.

**99.14** Tranche C is treated as described in [CRE99.7](#) to [CRE99.10](#).

**99.15** Tranche B (second-loss guarantee) is exposed only to dilution risk, but not to default risk. Therefore,  $K_{IRB}$  for the purpose of calculating a capital requirement for Tranche B, can be limited to  $K_{IRB,Dilution}$ . However, as the holder of Tranche B cannot be sure that Tranche C will still be available to cover the first dilution losses when they are realised – because the credit enhancement might already be depleted due to earlier default losses – to ensure a prudent treatment, it cannot recognise the purchase discount as credit enhancement for dilution risk. In the capital calculation, the bank providing Tranche B should assume that €50,000 of the securitised assets have already been defaulted and hence Tranche C is no longer available as credit enhancement and the exposure of the underlying assets has been reduced to €950,000. When calculating  $K_{IRB}$  for Tranche B, the bank can assume that  $K_{IRB}$  is not affected by the reduced portfolio size.

**99.16** RWA calculation for tranche B:

(1) Step 1: calculate  $K_{IRB,Pool}$ .

$$K_{IRB,Pool} = K_{IRB,Dilution} = 14.24\%$$

- (2) Step 2: apply the SEC-IRBA.
  - (a) Pool parameters:
    - (i)  $N = 100$
    - (ii)  $LGD_{\text{Pool}} = LGD_{\text{Dilution}} = 100\%$
  - (b) Tranche parameters:
    - (i)  $M_T = 2.5$  years
    - (ii) Attachment point = 0%
    - (iii) Detachment point =  $\text{€}250,000 / \text{€}950,000 = 26.32\%$
- (3) Resulting risk-weighted exposure amounts for tranche B:
  - (a) SEC-IRBA risk weight = 925.47%
  - (b) RWA =  $\text{€}2,313,675$

**99.17** The holder of Tranche A (senior note) will take all default losses not covered by the purchase discount and all dilution losses not covered by the purchase discount or the second-loss guarantee. A possible treatment for Tranche A would be to add  $K_{\text{IRB,Default}}$  and  $K_{\text{IRB,Dilution}}$  (as in [CRE99.7](#) to [CRE99.10](#)), but not to recognise the second-loss guarantee as credit enhancement at all because it is covering only dilution risk.

**99.18** Although this is a simple approach, it is also fairly conservative. Therefore the following alternative for the senior tranche could be considered:

- (1) Calculate the RWA amount for Tranche A under the assumption that it is only exposed to losses resulting from defaults. This assumption implies that Tranche A is benefiting from a credit enhancement of  $\text{€}50,000$ .
- (2) Calculate the RWA amounts for Tranche C and (hypothetical) Tranche A\* under the assumption that they are only exposed to dilution losses. Tranche A\* should be assumed to absorb losses above  $\text{€}300,000$  up to  $\text{€}1,000,000$ . With respect to dilution losses, this approach would recognise that the senior tranche investor cannot be sure if the purchase price discount will still be available to cover those losses when needed as it might have already been used for defaults. Consequently, from the perspective of the senior investor, the purchase price discount could only be recognised for the calculation of the capital requirement for default or dilution risk but not for both.<sup>7</sup>

- (3) Sum up the RWA amounts under [CRE99.18\(1\)](#) and [CRE99.18\(2\)](#) and apply the relevant risk weight floor in [CRE44.26](#) or [CRE44.29](#) to determine the final RWA amount for the senior note investor.

#### Footnotes

Z *In this example, the purchase price discount was recognised in the default risk calculation, but banks could also choose to use it for the dilution risk calculation. It is also assumed that the second-loss dilution guarantee explicitly covers dilution losses above €50,000 up to €300,000. If the guarantee instead covered €250,000 dilution losses after the purchase discount has been depleted (irrespective of whether the purchase discount has been used for dilution or default losses), then the senior note holder should assume that he is exposed to dilution losses from €250,000 up to €1,000,000 (instead of €0 to €50,000 + €300,000 to €1,000,000).*

#### **99.19** RWA calculation for tranche A:

- (1) Step 1: calculate RWA for [CRE99.18\(1\)](#).
- (a) Pool parameters:
- (i)  $K_{\text{IRB,Pool}} = K_{\text{IRB,Default}} = 7\%$
  - (ii)  $\text{LGD}_{\text{Pool}} = \text{LGD}_{\text{Default}} = 45\%$
- (b) Tranche parameters:
- (i)  $M_T = 2.5$  years
  - (ii) Attachment point = €50,000 / €1,000,000 = 5%
  - (iii) Detachment point = €1,000,000 / €1,000,000 = 100%
- (c) Resulting risk-weighted exposure amounts:
- (i) SEC-IRBA risk weight = 56.58%
  - (ii) RWA = €537,510.

(2) Step 2: calculate RWA for [CRE99.18\(2\)](#).

(a) Pool parameters:

(i)  $K_{IRB,Pool} = K_{IRB,Dilution} = 14.24\%$

(ii)  $LGD_{Pool} = LGD_{Dilution} = 100\%$

(b) Tranche parameters:

(i)  $M_T = 2.5$  years

(ii) Attachment and detachment points shown in Table 4

Attachment and detachment points for each tranche		Table 4
	Attachment point	Detachment point
Tranche A*	30%	100%
Tranche C	0%	5%

(c) Resulting risk-weighted exposure amounts shown in Table 5

Risk-weighted exposure amounts for each tranche		Table 5
	SEC-IRBA risk weight	RWA
Tranche A*	13.65%	€95,550
Tranche C	1250%	€625,000

**(3)** Step 3: Sum up the RWA of [CRE99.19\(1\)](#) and [CRE99.19\(2\)](#)<sup>8</sup>

(a) Final RWA amount for investor in Tranche A = €537,510 + €95,550 + €625,000 = €1,258,060

(b) Implicit risk weight for Tranche A =  $\max(15\%, \frac{€1,258,060}{€950,000}) = 132.43\%$

## Footnotes

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*The correct application of the overall risk weight floor is such that the intermediate results (in this case the risk weight for Tranche A\*) are calculated without the floor and the floor is only enforced in the last step (ie Step 3(b)).*

## Illustrative examples of the application of the SA-CCR to sample portfolios

**99.20** This section ([CRE99.20](#) to [CRE99.97](#)) sets out the calculation of exposure at default (EAD) for five sample portfolios using SA-CCR. The calculations for the sample portfolios assume that intermediate values are not rounded (ie the actual results are carried through in sequential order). However, for ease of presentation, these intermediate values as well as the final EAD are rounded.

**99.21** The EAD for all netting sets in SA-CCR is given by the following formula, where alpha is assigned a value of 1.4:

$$EAD = \alpha * (RC + multiplier * AddOn^{aggregate})$$

### Example 1: Interest rate derivatives (unmargined netting set)

**99.22** Netting set 1 consists of three interest rates derivatives: two fixed versus floating interest rate swaps and one purchased physically-settled European swaption. The table below summarises the relevant contractual terms of the three derivatives. All notional amounts and market values in the table are given in USD thousands.

Trade #	Nature	Residual maturity	Base currency	Notional (USD thousands)	Pay Leg (*)	Receive Leg (*)	Market value (USD thousands)
1	Interest rate swap	10 years	USD	10,000	Fixed	Floating	30
2	Interest rate swap	4 years	USD	10,000	Floating	Fixed	-20
3	European swaption	1 into 10 years	EUR	5,000	Floating	Fixed	50

(\*) For the swaption, the legs are those of the underlying swap

**99.23** The netting set is not subject to a margin agreement and there is no exchange of collateral (independent amount/initial margin) at inception. For unmargined netting sets, the replacement cost is calculated using the following formula, where:

- (1)  $V$  is a simple algebraic sum of the derivatives' market values at the reference date
- (2)  $C$  is the haircut value of the initial margin, which is zero in this example

$$RC = \max\{V - C; 0\}$$

**99.24** Thus, using the market values indicated in the table (expressed in USD thousands):

$$RC = \max\{30 - 20 + 50 - 0; 0\} = 60$$

**99.25** Since  $V - C$  is positive (ie USD 60,000), the value of the multiplier is 1, as explained in [CRE52.22](#).

**99.26** The remaining term to be calculated in the calculation EAD is the aggregate add-on ( $\text{AddOn}^{\text{aggregate}}$ ). All the transactions in the netting set belong to the interest rate asset class. The  $\text{AddOn}^{\text{aggregate}}$  for the interest rate asset class can be calculated using the seven steps set out in [CRE52.57](#).

**99.27** Step 1: Calculate the effective notional for each trade in the netting set. This is calculated as the product of the following three terms: (i) the adjusted notional of

the trade ( $d_i$ ); (ii) the supervisory delta adjustment of the trade ( $\delta_i$ ); and (iii) the maturity factor (MF). That is, for each trade  $i$ , the effective notional  $D_i$  is calculated as  $D_i = d_i * MF_i * \delta_i$ .

**99.28** For interest rate derivatives, the trade-level adjusted notional ( $d_i$ ) is the product of the trade notional amount and the supervisory duration ( $SD_i$ ), ie  $d_i = \text{notional} * SD_i$ . The supervisory duration is calculated using the following formula, where:

- (1)  $S_i$  and  $E_i$  are the start and end dates, respectively, of the time period referenced by the interest rate derivative (or, where such a derivative references the value of another interest rate instrument, the time period determined on the basis of the underlying instrument). If the start date has occurred (eg an ongoing interest rate swap),  $S_i$  must be set to zero.
- (2) The calculated value of  $SD_i$  is floored at 10 business days (which expressed in years, using an assumed market convention of 250 business days a year is 10 /250 years).

$$SD_i = \frac{\exp(-0.05 * S_i) - \exp(-0.05 * E_i)}{0.05}$$

**99.29** Using the formula for supervisory duration above, the trade-level adjusted notional amounts for each of the trades in Example 1 are as follows:

Trade #	Notional (USD thousands)	$S_i$	$E_i$	$SD_i$	Adjusted notional, $d_i$ (USD thousands)
1	10,000	0	10	7.87	78,694
2	10,000	0	4	3.63	36,254
3	5,000	1	11	7.49	37,428

**99.30** [CRE52.48](#) sets out the calculation of the maturity factor ( $MF_i$ ) for unmargined trades. For trades that have a remaining maturity in excess of one year, which is the case for all trades in this example, the formula gives a maturity factor of 1.



**99.31** As set out in [CRE52.38](#) to [CRE52.41](#), a supervisory delta is assigned to each trade. In particular:

- (1) Trade 1 is long in the primary risk factor (the reference floating rate) and is not an option so the supervisory delta is equal to 1.
- (2) Trade 2 is short in the primary risk factor and is not an option; thus, the supervisory delta is equal to -1.
- (3) Trade 3 is an option to enter into an interest rate swap that is short in the primary risk factor and therefore is treated as a bought put option. As such, the supervisory delta is determined by applying the relevant formula in [CRE52.40](#), using 50% as the supervisory option volatility and 1 (year) as the option exercise date. In particular, assuming that the underlying price (the appropriate forward swap rate) is 6% and the strike price (the swaption's fixed rate) is 5%, the supervisory delta is:

$$\delta_i = -\Phi\left(-\frac{\ln(0.06 / 0.05) + 0.5 \cdot 0.5^2 \cdot 1}{0.5 \cdot \sqrt{1}}\right) = -0.2694$$

**99.32** The effective notional for each trade in the netting set ( $D_i$ ) is calculated using the formula  $D_i = d_i * MF_i * \delta_i$  and values for each term noted above. The results of applying the formula are as follows:

Trade #	Notional (USD thousands)	Adjusted notional, $d_i$ (USD, thousands)	Maturity Factor, $MF_i$	Delta, $\delta_i$	Effective notional, $D_i$ (USD, thousands)
1	10,000	78,694	1	1	78,694
2	10,000	36,254	1	-1	-36,254
3	5,000	37,428	1	-0.2694	-10,083

**99.33** Step 2: Allocate the trades to hedging sets. In the interest rate asset class the hedging sets consist of all the derivatives that reference the same currency. In this example, the netting set is comprised of two hedging sets, since the trades refer to interest rates denominated in two different currencies (USD and EUR).

**99.34** Step 3: Within each hedging set allocate each of the trades to the following three maturity buckets: less than one year (bucket 1), between one and five years (bucket 2) and more than five years (bucket 3). For this example, within the hedging set "USD", trade 1 falls into the third maturity bucket (more than 5 years) and trade 2 falls into the second maturity bucket (between one and five years). Trade 3 falls into the third maturity bucket (more than 5 years) of the hedging set "EUR". The results of steps 1 to 3 are summarised in the table below:

Trade #	Effective notional, $D_i$ (USD, thousands)	Hedging set	Maturity bucket
1	78,694	USD	3
2	-36,254	USD	2
3	-10,083	EUR	3

**99.35** Step 4: Calculate the effective notional of each maturity bucket ( $D^{B1}$ ,  $D^{B2}$  and  $D^{B3}$ ) within each hedging set (USD and EUR) by adding together all the trade level effective notionals within each maturity bucket in the hedging set. In this example, there are no maturity buckets within a hedging set with more than one trade, and so in this case the effective notional of each maturity bucket is simply equal to the effective notional of the single trade in each bucket. Specifically:

- (1) For the USD hedging set:  $D^{B1}$  is zero,  $D^{B2}$  is -36,254 (thousand USD) and  $D^{B3}$  is 78,694 (thousand USD).
- (2) For the EUR hedging set:  $D^{B1}$  and  $D^{B2}$  are zero and  $D^{B3}$  is -10,083 (thousand USD).

**99.36** Step 5: Calculate the effective notional of the hedging set ( $EN_{HS}$ ) by using either of the two following aggregation formulas (the latter is to be used if the bank chooses not to recognise offsets between long and short positions across maturity buckets):

$$\text{Offset formula: } EN_{hs} = \left[ (D^{B1})^2 + (D^{B2})^2 + (D^{B3})^2 + 1.4 * D^{B1} * D^{B2} + 1.4 * D^{B2} * D^{B3} + 0.6 * D^{B1} * D^{B3} \right]^{\frac{1}{2}}$$

$$\text{No offset formula: } EN_{hs} = |D^{B1}| + |D^{B2}| + |D^{B3}|$$

**99.37** In this example, the first of the two aggregation formulas is used. Therefore, the effective notionals for the USD hedging set ( $EN_{USD}$ ) and the EUR hedging ( $EN_{EUR}$ ) are, respectively (expressed in USD thousands):

$$EN_{USD} = \left[ (-36,254)^2 + (78,694)^2 + 1.4 * (-36,254) * 78,694 \right]^{\frac{1}{2}} = 59,270$$

$$EN_{EUR} = \left[ (-10,083)^2 \right]^{\frac{1}{2}} = 10,083$$

**99.38** Step 6: Calculate the hedging set level add-on ( $AddOn_{hs}$ ) by multiplying the effective notional of the hedging set ( $EN_{hs}$ ) by the prescribed supervisory factor ( $SF_{hs}$ ). The prescribed supervisory factor in the interest rate asset class is set at 0.5%. Therefore, the add-on for the USD and EUR hedging sets are, respectively (expressed in USD thousands):

$$AddOn_{USD} = 59,270 * 0.005 = 296.35$$

$$AddOn_{EUR} = 10,083 * 0.005 = 50.415$$

**99.39** Step 7: Calculate the asset class level add-on ( $AddOn^{IR}$ ) by adding together all of the hedging set level add-ons calculated in step 6. Therefore, the add-on for the interest rate asset class is (expressed in USD thousands):

$$AddOn^{IR} = 296.35 + 50.415 = 347$$

**99.40** For this netting set the interest rate add-on is also the aggregate add-on because there are no derivatives belonging to other asset classes. The EAD for the netting set can now be calculated using the formula set out in [CRE99.21](#) (expressed in USD thousands):

$$EAD = \alpha * (RC + multiplier * AddOn^{aggregate}) = 1.4 * (60 + 1 * 347) = 569$$

## Example 2 : Credit derivatives (unmargined netting set)

**99.41** Netting set 2 consists of three credit derivatives: one long single-name credit default swap (CDS) written on Firm A (rated AA), one short single-name CDS written on Firm B (rated BBB), and one long CDS index (investment grade). The table below summarises the relevant contractual terms of the three derivatives. All notional amounts and market values in the table are in USD thousands.

<b>Trade #</b>	<b>Nature</b>	<b>Reference entity / index name</b>	<b>Rating reference entity</b>	<b>Residual maturity</b>	<b>Base currency</b>	<b>Notional (USD thousands)</b>	<b>Position</b>	<b>Market value (USD thousands)</b>
1	Single-name CDS	Firm A	AA	3 years	USD	10,000	Protection buyer	20
2	Single-name CDS	Firm B	BBB	6 years	EUR	10,000	Protection seller	-40
3	CDS index	CDX.IG 5y	Investment grade	5 years	USD	10,000	Protection buyer	0

**99.42** As in the previous example, the netting set is not subject to a margin agreement and there is no exchange of collateral (independent amount/initial margin) at inception. For unmargined netting sets, the replacement cost is calculated using the following formula, where:

- (1)  $V$  is a simple algebraic sum of the derivatives' market values at the reference date
- (2)  $C$  is the haircut value of the initial margin, which is zero in this example

$$RC = \max\{V - C; 0\}$$

**99.43** Thus, using the market values indicated in the table (expressed in USD thousands):

$$RC = \max\{20 - 40 + 0 - 0; 0\} = 0$$

**99.44** Since in this example  $V-C$  is negative (equal to  $V$ , ie -20,000), the multiplier will be activated (ie it will be less than 1). Before calculating its value, the aggregate add-on ( $\text{AddOn}^{\text{aggrerate}}$ ) needs to be determined.

**99.45** All the transactions in the netting set belong to the credit derivatives asset class. The  $\text{AddOn}^{\text{aggrerate}}$  for the credit derivatives asset class can be calculated using the four steps set out in [CRE52.61](#).

**99.46** Step 1: Calculate the effective notional for each trade in the netting set. This is calculated as the product of the following three terms: (i) the adjusted notional of the trade ( $d_i$ ); (ii) the supervisory delta adjustment of the trade ( $\delta_i$ ); and (iii) the maturity factor (MF). That is, for each trade  $i$ , the effective notional  $D_i$  is calculated as  $D_i = d_i * MF_i * \delta_i$ .

**99.47** For credit derivatives, like interest rate derivatives, the trade-level adjusted notional ( $d_i$ ) is the product of the trade notional amount and the supervisory duration ( $SD_i$ ), ie  $d_i = \text{notional} * SD_i$ . The trade-level adjusted notional amounts for each of the trades in Example 2 are as follows:

Trade #	Notional (USD thousands)	$S_i$	$E_i$	$SD_i$	Adjusted notional, $d_i$ (USD thousands)
1	10,000	0	3	2.79	27,858
2	10,000	0	6	5.18	51,836
3	10,000	0	5	4.42	44,240

**99.48** [CRE52.48](#) sets out the calculation of the maturity factor ( $MF_i$ ) for unmargined trades. For trades that have a remaining maturity in excess of one year, which is the case for all trades in this example, the formula gives a maturity factor of 1.

**99.49** As set out in [CRE52.38](#) to [CRE52.41](#), a supervisory delta is assigned to each trade. In particular:

- (1) Trade 1 and Trade 3 are long in the primary risk factors (CDS spread) and are not options so the supervisory delta is equal to 1 for each trade.
- (2) Trade 2 is short in the primary risk factor and is not an option; thus, the supervisory delta is equal to -1.

**99.50** The effective notional for each trade in the netting set ( $D_i$ ) is calculated using the formula  $D_i = d_i * MF_i * \delta_i$  and values for each term noted above. The results of applying the formula are as follows:

Trade #	Notional (USD thousands)	Adjusted notional, $d_i$ (USD, thousands)	Maturity Factor, $MF_i$	Delta, $\delta_i$	Effective notional, $D_i$ (USD, thousands)
1	10,000	27,858	1	1	27,858
2	10,000	51,836	1	-1	-51,836
3	10,000	44,240	1	1	44,240

**99.51** Step 2: Calculate the combined effective notional for all derivatives that reference the same entity. The combined effective notional of the entity ( $EN_{entity}$ ) is calculated by adding together the trade level effective notionals calculated in step 1 that reference that entity. However, since all the derivatives refer to different entities (single names/indices), the effective notional of the entity is simply equal to the trade level effective notional ( $D_i$ ) for each trade.

**99.52** Step 3: Calculate the add-on for each entity ( $AddOn_{entity}$ ) by multiplying the entity level effective notional in step 2 by the supervisory factor that is specified for that entity ( $SF_{entity}$ ). The supervisory factors are set out in table 2 in [CRE52.72](#). A supervisory factor is assigned to each single-name entity based on the rating of the reference entity (0.38% for AA-rated firms and 0.54% for BBB-rated firms). For CDS indices, the SF is assigned according to whether the index is investment or speculative grade; in this example, its value is 0.38% since the index is investment grade. Thus, the entity level add-ons are the following (USD thousands):

Reference Entity	Effective notional, $D_i$ (USD, thousands)	Supervisory factor, $SF_{entity}$	Entity-level add-on, $AddOn_{entity} (=D_i * SF_{entity})$
Firm A	27,858	0.38%	106
Firm B	-51,836	0.54%	-280
CDX.IG	44,240	0.38%	168

**99.53** Step 4: Calculate the asset class level add-on ( $AddOn^{Credit}$ ) by using the formula that follows, where:

- (1) The summations are across all entities referenced by the derivatives.
- (2)  $AddOn_{entity}$  is the add-on amount calculated in step 3 for each entity referenced by the derivatives.
- (3)  $\rho_{entity}$  is the supervisory prescribed correlation factor corresponding to the entity. As set out in table 2 in [CRE52.72](#), the correlation factor is 50% for single entities (Firm A and Firm B) and 80% for indexes (CDX.IG).

$$AddOn^{Credit} = \left[ \underbrace{\left( \sum_{entity} \rho_{entity} * AddOn_{entity} \right)^2}_{\text{idiosyncratic component}} + \sum_{entity} \underbrace{\left( 1 - (\rho_{entity})^2 \right) * (AddOn_{entity})^2}_{\text{idiosyncratic component}} \right]^{\frac{1}{2}}$$

**99.54** The following table shows a simple way to calculate of the systematic and idiosyncratic components in the formula:

Reference Entity	$\rho_{\text{entity}}$	AddOn <sub>entity</sub>	$\rho_{\text{entity}} * \text{AddOn}_{\text{entity}}$	$1 - (\rho_{\text{entity}})^2$	$(\text{AddOn}_{\text{entity}})^2$	$(1 - (\rho_{\text{entity}})^2) * (\text{AddOn}_{\text{entity}})^2$
Firm A	0.5	106	52.9	0.75	11,207	8,405
Firm B	0.5	-280	-140	0.75	78,353	58,765
CDX.IG	0.8	168	134.5	0.36	28,261	10,174
<b>sum =</b>			47.5			<b>77,344</b>
<b>(sum)<sup>2</sup> =</b>			<b>2,253</b>			

**99.55** According to the calculations in the table, the systematic component is 2,253, while the idiosyncratic component is 77,344. Thus, the add-on for the credit asset class is calculated as follows:

$$\text{AddOn}^{\text{Credit}} = \left[ 2,253 + 77,344 \right]^{\frac{1}{2}} = 282$$

**99.56** For this netting set the credit add-on ( $\text{AddOn}^{\text{Credit}}$ ) is also the aggregate add-on ( $\text{AddOn}^{\text{aggregate}}$ ) because there are no derivatives belonging to other asset classes.

**99.57** The value of the multiplier can now be calculated as follows, using the formula set out in [CRE52.23](#):

$$\text{multiplier} = \min \left\{ 1; 0.05 + 0.95 * \exp \left( \frac{-20}{2 * 0.95 * 282} \right) \right\} = 0.965$$

**99.58** Finally, aggregating the replacement cost and the potential future exposure (PFE) component and multiplying the result by the alpha factor of 1.4, the EAD is as follows (USD thousands):

$$\text{EAD} = 1.4 * (0 + 0.965 * 282) = 381$$

### Example 3 : Commodity derivatives (unmargined netting set)

**99.59** Netting set 3 consists of three commodity forward contracts. The table below summarises the relevant contractual terms of the three derivatives. All notional amounts and market values in the table are in USD thousands.



Trade #	Notional	Nature	Underlying	Direction	Residual maturity	Market value
1	10,000	Forward	(West Texas Intermediate, or WTI) Crude Oil	Long	9 months	-50
2	20,000	Forward	(Brent) Crude Oil	Short	2 years	-30
3	10,000	Forward	Silver	Long	5 years	100

**99.60** As in the previous two examples, the netting set is not subject to a margin agreement and there is no exchange of collateral (independent amount/initial margin) at inception. Thus, the replacement cost is given by:

$$RC = \max\{V - C; 0\} = \max\{100 - 30 - 50 - 0; 0\} = 20$$

**99.61** Since  $V - C$  is positive (ie USD 20,000), the value of the multiplier is 1, as explained in [CRE52.22](#).

**99.62** All the transactions in the netting set belong to the commodities derivatives asset class. The  $\text{AddOn}^{\text{aggragate}}$  for the commodities derivatives asset class can be calculated using the six steps set out in [CRE52.70](#).

**99.63** Step 1: Calculate the effective notional for each trade in the netting set. This is calculated as the product of the following three terms: (i) the adjusted notional of the trade ( $d$ ); (ii) the supervisory delta adjustment of the trade ( $\delta$ ); and (iii) the maturity factor (MF). That is, for each trade  $i$ , the effective notional  $D_i$  is calculated as  $D_i = d_i * MF_i * \delta_i$ .

**99.64** For commodity derivatives, the adjusted notional is defined as the product of the current price of one unit of the commodity (eg barrel of oil) and the number of units referenced by the derivative. In this example, for the sake of simplicity, it is assumed that the adjusted notional ( $d_i$ ) is equal to the notional value.

**99.65** [CRE52.48](#) sets out the calculation of the maturity factor ( $MF_i$ ) for unmargined trades. For trades that have a remaining maturity in excess of one year (trades 2 and 3 in this example), the formula gives a maturity factor of 1. For trade 1 the formula gives the following maturity factor:

$$MF = \sqrt{\frac{\min\{M_i; 1\text{year}\}}{1\text{year}}} = \sqrt{\frac{\min\{9/12; 1\}}{1}} = \sqrt{9/12}$$

**99.66** As set out in [CRE52.38](#) to [CRE52.41](#), a supervisory delta is assigned to each trade. In particular:

- (1) Trade 1 and Trade 3 are long in the primary risk factors (WTI Crude Oil and Silver respectively) and are not options so the supervisory delta is equal to 1 for each trade.
- (2) Trade 2 is short in the primary risk factor (Brent Crude Oil) and is not an option; thus, the supervisory delta is equal to -1.

Trade #	Notional (USD thousands)	Adjusted notional, $d_i$ (USD, thousands)	Maturity Factor, $MF_i$	Delta, $\delta_i$	Effective notional, $D_i$ (USD, thousands)
1	10,000	10,000	$(9/12)^{0.5}$	1	8,660
2	20,000	20,000	1	-1	-20,000
3	10,000	10,000	1	1	10,000

**99.67** Step 2: Allocate the trades in commodities asset class to hedging sets. In the commodities asset class there are four hedging sets consisting of derivatives that reference: energy (trades 1 and 2 in this example), metals (trade 3 in this example), agriculture and other commodities.

Hedging set	Commodity type	Trades
Energy	Crude oil	1 and 2
	Natural gas	None
	Coal	None
	Electricity	None
Metals	Silver	3
	Gold	None
	...	...
Agriculture	...	...
	...	...
Other	...	...

Trade #	Effective notional, $D_i$ (USD, thousands)	Hedging set	Commodity type
1	8,660	Energy	Crude oil
2	-20,000	Energy	Crude oil
3	10,000	Metals	Silver

**99.68** Step 3: Calculate the combined effective notional for all derivatives with each hedging set that reference the same commodity type. The combined effective notional of the commodity type ( $EN_{ComType}$ ) is calculated by adding together the trade level effective notionals calculated in step 1 that reference that commodity type. For purposes of this calculation, the bank can ignore the basis difference between the WTI and Brent forward contracts since they belong to the same commodity type, "Crude Oil" (unless the national supervisor requires the bank to use a more refined definition of commodity types). This step gives the following:

$$(1) \quad EN_{CrudeOil} = 8,660 + (-20,000) = -11,340$$

$$(2) \quad EN_{Silver} = 10,000$$

**99.69** Step 4: Calculate the add-on for each commodity type ( $AddOn_{ComType}$ ) within each hedging set by multiplying the combined effective notional for that commodity calculated in step 3 by the supervisory factor that is specified for that commodity type ( $SF_{ComType}$ ). The supervisory factors are set out in table 2 in [CRE52.72](#) and are set at 40% for electricity derivatives and 18% for derivatives that reference all other types of commodities. Therefore:

$$(1) \quad AddOn_{CrudeOil} = -11,340 * 0.18 = -2,041$$

$$(2) \quad AddOn_{Silver} = 10,000 * 0.18 = 1,800$$

**99.70** Step 5: Calculate the add-on for each of the four commodity hedging sets ( $AddOn_{HS}$ ) by using the formula that follows. In the formula:

- (1) The summations are across all commodity types within the hedging set.
- (2)  $AddOn_{ComType}$  is the add-on amount calculated in step 4 for each commodity type.
- (3)  $\rho_{ComType}$  is the supervisory prescribed correlation factor corresponding to the commodity type. As set out in table 2 in [CRE52.72](#), the correlation factor is set 40% for all commodity types.

$$AddOn_{HS} = \left[ \left( \sum_{ComType} \rho_{ComType} * AddOn_{ComType} \right)^2 + \sum_{ComType} \left( 1 - (\rho_{ComType})^2 \right) * \left( AddOn_{ComType} \right)^2 \right]^{\frac{1}{2}}$$

**99.71** In this example, however, there is only one commodity type within the “Energy” hedging set (ie Crude Oil). All other commodity types within the energy hedging set (eg coal, natural gas etc) have a zero add-on. Therefore, the add-on for the energy hedging set is calculated as follows:

$$AddOn_{Energy} = \left[ \left( \rho_{CrudeOil} * AddOn_{CrudeOil} \right)^2 + \left( 1 - (\rho_{CrudeOil})^2 \right) * \left( AddOn_{CrudeOil} \right)^2 \right]^{\frac{1}{2}}$$

$$AddOn_{Energy} = \left[ \left( 0.4 * (-2,041) \right)^2 + \left( 1 - (0.4)^2 \right) * \left( -2,041 \right)^2 \right]^{\frac{1}{2}} = 2,041$$

**99.72** The calculation above shows that, when there is only one commodity type within a hedging set, the hedging-set add-on is equal (in absolute value) to the commodity-type add-on.

**99.73** Similarly, “Silver” is the only commodity type in the “Metals” hedging set, and so the add-on for the metals hedging set is:

$$AddOn_{Metals} = |AddOn_{Silver}| = 1,800$$

**99.74** Step 6: Calculate the asset class level add-on ( $AddOn^{Commodity}$ ) by adding together all of the hedging set level add-ons calculated in step 5:

$$AddOn^{Commodity} = \sum_{HS} AddOn_{HS} = AddOn_{Energy} + AddOn_{Metals} = 2,041 + 1,800 = 3841$$

**99.75** For this netting set the commodity add-on ( $AddOn^{Commodity}$ ) is also the aggregate add-on ( $AddOn^{aggregate}$ ) because there are no derivatives belonging to other asset classes.

**99.76** Finally, aggregating the replacement cost and the PFE component and multiplying the result by the alpha factor of 1.4, the EAD is as follows (USD thousands):

$$EAD = 1.4 * (20 + 1 * 3,841) = 5,406$$

#### **Example 4 : Interest rate and credit derivatives (unmargined netting set)**

**99.77** Netting set 4 consists of the combined trades of Examples 1 and 2. There is no margin agreement and no collateral. The replacement cost of the combined netting set is:

$$RC = \max\{V - C; 0\} = \max\{30 - 20 + 50 + 20 - 40 + 0; 0\} = 40$$

**99.78** The aggregate add-on for the combined netting set is the sum of add-ons for each asset class. In this case, there are two asset classes, interest rates and credit, and the add-ons for these asset classes have been copied from Examples 1 and 2:

$$AddOn^{aggregate} = AddOn^{IR} + AddOn^{Credit} = 347 + 282 = 629$$

**99.79** Because V-C is positive, the multiplier is equal to 1. Finally, the EAD can be calculated as:

$$EAD = 1.4 * (40 + 1 * 629) = 936$$

#### **Example 5 : Interest rate and commodities derivatives (margined netting set)**

**99.80** Netting set 5 consists of the combined trades of Examples 1 and 3. However, instead of being unmargined (as assumed in those examples), the trades are subject to a margin agreement with the following specifications:

Margin frequency	Threshold, TH	Minimum Transfer Amount, MTA (USD thousands)	Independent Amount, IA (USD thousands)	Total net collateral held by bank (USD thousands)
Weekly	0	5	150	200

**99.81** The above table depicts a situation in which the bank received from the counterparty a net independent amount of 150 (taking into account the net amount of initial margin posted by the counterparty and any unsegregated initial margin posted by the bank). The total net collateral (after the application of haircuts) currently held by the bank is 200, which includes 50 for variation margin received and 150 for the net independent amount.

**99.82** First, we determine the replacement cost. The net collateral currently held is 200 and the net independent collateral amount (NICA) is equal to the independent amount (that is, 150). The current market value of the trades in the netting set ( $V$ ) is 80, it is calculated as the sum of the market value of the trades, ie  $30 - 20 + 50 - 50 - 30 + 100 = 80$ . The replacement cost for margined netting sets is calculated using the formula set out in [CRE52.18](#). Using this formula the replacement cost for the netting set in this example is:

$$RC = \max\{V - C; TH + MTA - NICA; 0\} = \max\{80 - 200; 0 + 5 - 150; 0\} = 0$$

**99.83** Second, it is necessary to recalculate the interest rate and commodity add-ons, based on the value of the maturity factor for margined transactions, which depends on the margin period of risk. For daily re-margining, the margin period of risk (MPOR) would be 10 days. In accordance with [CRE52.50](#), for netting sets that are not subject daily margin agreements the MPOR is the sum of nine business days plus the re-margining period (which is five business days in this example). Thus the MPOR is 14 (= 9 + 5) in this example.

**99.84** The re-scaled maturity factor for the trades in the netting set is calculated using the formula set out in [CRE52.52](#). Using the MPOR calculated above, the maturity factor for all trades in the netting set in this example it is calculated as follows (a market convention of 250 business days in the financial year is used):

$$MF_i^{(\text{margined})} = \frac{3}{2} \sqrt{\frac{MPOR_i}{1 \text{ year}}} = 1.5 * \sqrt{14/250}$$

**99.85**

For the interest rate add-on, the effective notional for each trade ( $D_i = d_i * MF_i * \delta_i$ ) calculated in [CRE99.32](#) must be recalculated using the maturity factor for the margined netting set calculated above. That is:

IR Trade #	Notional (USD thousands)	Base currency (hedging set)	Maturity bucket	Adjusted notional, $d_i$ (USD, thousands)	Maturity Factor, $MF_i$	Delta, $\delta_i$	Effective notional (USD thousands)
1	10,000	USD	3	78,694	$1.5 * \sqrt{14/250}$	1	27,934
2	10,000	USD	2	36,254	$1.5 * \sqrt{14/250}$	-1	-12,869
3	5,000	EUR	3	37,428	$1.5 * \sqrt{14/250}$	-0.2694	-3,579

**99.86** Next, the effective notional of each of the three maturity buckets within each hedging set must now be calculated. However, as set out in [CRE99.35](#), given that in this example there are no maturity buckets within a hedging set with more than a single trade, the effective maturity of each maturity bucket is simply equal to the effective notional of the single trade in each bucket. Specifically:

- (1) For the USD hedging set:  $D^{B1}$  is zero,  $D^{B2}$  is -12,869 (thousand USD) and  $D^{B3}$  is 27,934 (thousand USD).
- (2) For the EUR hedging set:  $D^{B1}$  and  $D^{B2}$  are zero and  $D^{B3}$  is -3,579 (thousand USD).

**99.87** Next, the effective notional of each of the two hedging sets (USD and EUR) must be recalculated using formula set out in [CRE99.37](#) and the updated values of the effective notionals of each maturity bucket. The calculation is as follows:

$$EN_{USD} = \left[ (-12,869)^2 + (27,934)^2 + 1.4 * (-12,869) * 27,934 \right]^{\frac{1}{2}} = 21,039$$

$$EN_{EUR} = \left[ (-3,579)^2 \right]^{\frac{1}{2}} = 3,579$$

**99.88** Next, the hedging set level add-ons ( $AddOn_{hs}$ ) must be recalculated by multiplying the recalculated effective notionals of each hedging set ( $EN_{hs}$ ) by the prescribed supervisory factor of the hedging set ( $SF_{hs}$ ). As set out in [CRE99.35](#),

the prescribed supervisory factor in this case is 0.5%. Therefore, the add-on for the USD and EUR hedging sets are, respectively (expressed in USD thousands):

$$AddOn_{USD} = 21,039 * 0.005 = 105$$

$$AddOn_{EUR} = 3,579 * 0.005 = 18$$

**99.89** Finally, the interest rate asset class level add-on ( $AddOn_{IR}$ ) can be recalculated by adding together the USD and EUR hedging set level add-ons as follows (expressed in USD thousands):

$$AddOn^{IR} = 105 + 18 = 123$$

**99.90** The add-on for the commodity asset class must also be recalculated using the maturity factor for the margined netting. The effective notional for each trade ( $Di = di * MF_i * \delta_i$ ) is set out in the table below:

Commodity Trade #	Notional (USD thousands)	Hedging set	Commodity type	Adjusted notional, $d_i$ (USD, thousands)	Maturity Factor, $MF_i$	Delta, $\delta_i$
1	10,000	Energy	Crude Oil	10,000	$1.5 * \sqrt{14/250}$	1
2	20,000	Energy	Crude Oil	20,000	$1.5 * \sqrt{14/250}$	-1
3	10,000	Metals	Silver	10,000	$1.5 * \sqrt{14/250}$	1

**99.91** The combined effective notional for all derivatives with each hedging set that reference the same commodity type ( $EN_{ComType}$ ) must be recalculated by adding together the trade level effective notionals above for each commodity type. This gives the following:

$$(1) EN_{CrudeOil} = 3,550 + (-7,100) = -3,550$$

$$(2) EN_{Silver} = 3,550$$



**99.92**

The add-on for each commodity type ( $AddOn_{CrudeOil}$  and  $AddOn_{Silver}$ ) within each hedging set calculated in [CRE99.69](#) must now be recalculated by multiplying the recalculated combined effective notional for that commodity by the relevant supervisory factor (ie 18%). Therefore:

$$(1) \quad AddOn_{CrudeOil} = -3,550 * 0.18 = -639$$

$$(2) \quad AddOn_{Silver} = 3550 * 0.18 = 639$$

**99.93** Next, recalculate the add-on for energy and metals hedging sets using the recalculated add-ons for each commodity type above. As noted in [CRE99.72](#), given that there is only one commodity type with each hedging set, the hedging set level add on is simply equal to the absolute value of the commodity type add-on. That is:

$$AddOn_{Energy} = |AddOn_{CrudeOil}| = 639$$

$$AddOn_{Metals} = |AddOn_{Silver}| = 639$$

**99.94** Finally, calculate the commodity asset class level add-on ( $AddOn^{Commodity}$ ) by adding together the hedging set level add-ons:

$$AddOn^{Commodity} = \sum_{HS} AddOn_{HS} = 639 + 639 = 1,278$$

**99.95** The aggregate netting set level add-on can now be calculated. As set out in [CRE52.25](#), it is calculated as the sum of the asset class level add-ons. That is for this example:

$$AddOn^{aggregate} = \sum_{assetclass} AddOn^{(assetclass)} = AddOn^{IR} + AddOn^{Commodity} = 123 + 1,278 = 1,401$$

**99.96** As can be seen from [CRE99.82](#), the value of V-C is negative (ie -120) and so the multiplier will be less than 1. The multiplier is calculated using the formula set out in [CRE52.23](#), which for this example gives:

$$multiplier = \min\left(1; 0.05 + 0.95 * \exp\left(\frac{80 - 200}{2 * 0.95 * 1,401}\right)\right) = 0.958$$

**99.97** Finally, aggregating the replacement cost and the PFE component and multiplying the result by the alpha factor of 1.4, the EAD is as follows (USD thousands):

$$EAD = 1.4 * (0 + 0.958 * 1,401) = 1,879$$

## Effect of standard margin agreements on the calculation of replacement cost with SA-CCR

**99.98** In this section ([CRE99.98](#) to [CRE99.115](#)), five examples are used to illustrate the operation of the SA-CCR in the context of standard margin agreements. In particular, they relate to the formulation of replacement cost for margined trades, as set out in [CRE52.18](#):

$$RC = \max\{V - C; TH + MTA - NICA; 0\}$$

### Example 1

**99.99** The bank currently has met all past variation margin (VM) calls so that the value of trades with its counterparty (€80 million) is offset by cumulative VM in the form of cash collateral received. There is a small "Minimum Transfer Amount" (MTA) of €1 million and a €0 "Threshold" (TH). Furthermore, an "Independent Amount" of €10 million is agreed in favour of the bank and none in favour of its counterparty (ie the NICA is €10 million. This leads to a credit support amount of €90 million, which is assumed to have been fully received as of the reporting date.

**99.100** In this example, the three terms in the replacement formula are:

- (1)  $V - C = €80 \text{ million} - €90 \text{ million} = \text{negative } €10 \text{ million.}$
- (2)  $TH + MTA - NICA = €0 + €1 \text{ million} - €10 \text{ million} = \text{negative } €9 \text{ million.}$
- (3) The third term in the replacement cost formula is always zero, which ensures that replacement cost is not negative.

**99.101** The highest of the three terms (-€10 million, -€9 million, 0) is zero, so the replacement cost is zero. This is due to the large amount of collateral posted by the bank's counterparty.

### Example 2

**99.102**The counterparty has met all VM calls but the bank has some residual exposure due to the MTA of €1 million in its master agreement, and has a €0 TH. The value of the bank's trades with the counterparty is €80 million and the bank holds €79.5 million in VM in the form of cash collateral. In addition, the bank holds €10 million in independent collateral (here being an initial margin independent of VM, the latter of which is driven by mark-to-market (MTM) changes) from the counterparty. The counterparty holds €10 million in independent collateral from the bank, which is held by the counterparty in a non-segregated manner. The NICA is therefore €0 (= €10 million independent collateral held less €10 million independent collateral posted).

**99.103**In this example, the three terms in the replacement formula are:

- (1)  $V - C = €80 \text{ million} - (€79.5 \text{ million} + €10 \text{ million} - €10 \text{ million}) = €0.5 \text{ million}.$
- (2)  $TH + MTA - NICA = €0 + €1 \text{ million} - €0 = €1 \text{ million}.$
- (3) The third term is zero.

**99.104**The replacement cost is the highest of the three terms (€0.5 million, €1 million, 0) which is €1 million. This represents the largest exposure before collateral must be exchanged.

### **Bank as a clearing member**

**99.105**The case of central clearing can be viewed from a number of perspectives. One example in which the replacement cost formula for margined trades can be applied is when the bank is a clearing member and is calculating replacement cost for its own trades with a central counterparty (CCP). In this case, the MTA and TH are generally zero. VM is usually exchanged at least daily and the independent collateral amount (ICA) in the form of a performance bond or initial margin is held by the CCP.

### **Example 3**

**99.106**The bank, in its capacity as clearing member of a CCP, has posted VM to the CCP in an amount equal to the value of the trades it has with the CCP. The bank has posted cash as initial margin and the CCP holds the initial margin in a bankruptcy remote fashion. Assume that the value of trades with the CCP are negative €50 million, the bank has posted €50 million in VM and €10 million in initial margin (IM) to the CCP.

**99.107** Given that the IM is held by the CCP in a bankruptcy-remote fashion, [CRE52.17](#) permits this amount to be excluded in the calculation of NICA. Therefore, the NICA is €0 because the bankruptcy IM posted to the CCP can be excluded and the bank has not received any IM from the CCP. The value of C is calculated as the value of NICA plus any VM received less any VM posted. The value of C is thus negative €50 million (= €0 million + €0 million - €50 million).

**99.108** In this example, the three terms in the replacement cost formula are:

- (1)  $V - C = (-€50 \text{ million}) - (-€50 \text{ million}) = €0$ . That is, the negative value of the trades has been fully offset by the VM posted by the bank.
- (2)  $TH + MTA - NICA = €0 + €0 - €0 = €0$ .
- (3) The third term is zero.

**99.109** The replacement cost is therefore €0.

#### **Example 4**

**99.110** Example 4 is the same as the Example 3, except that the IM posted to the CCP is not bankruptcy-remote. As a consequence, the €10 million of IM must be included in the calculation of NICA. Thus, NICA is negative €10 million (= ICA received of €0 minus unsegregated ICA posted of €10 million). Also, the value of C is negative €60 million (= NICA + VM received - VM posted = -€10 million + €0 - €50 million).

**99.111** In this example, the three terms in the replacement formula are:

- (1)  $V - C = (-€50 \text{ million}) - (-€60 \text{ million}) = €10 \text{ million}$ . That is, the negative value of the trades is more than fully offset by collateral posted by the bank.
- (2)  $TH + MTA - NICA = €0 + €0 - (-€10 \text{ million}) = €10 \text{ million}$ .
- (3) The third term is zero.

**99.112** The replacement cost is therefore €10 million. This represents the IM posted to the CCP which risks being lost upon default and bankruptcy of the CCP.

#### **Example 5 : Maintenance Margin Agreement**

**99.113** Some margin agreements specify that a counterparty (in this case, a bank) must maintain a level of collateral that is a fixed percentage of the MTM of the

transactions in a netting set. For this type of margining agreement, ICA is the amount of collateral that the counterparty must maintain above the net MTM of the transactions.

**99.114** For example, suppose the agreement states that a counterparty must maintain a collateral balance of at least 140% of the MTM of its transactions and that the MTM of the derivatives transactions is €50 in the bank's favour. ICA in this case is €20 (= 140% \* €50 – €50). Further, suppose there is no TH, no MTA, the bank has posted no collateral and the counterparty has posted €80 in cash collateral. In this example, the three terms of the replacement cost formula are:

- (1)  $V - C = €50 - €80 = -€30$ .
- (2)  $MTA + TH - NICA = €0 + €0 - €20 = -€20$ .
- (3) The third term is zero.

**99.115** Thus, the replacement cost is zero in this example.

### **Equity investments in funds: calculation of risk-weighted assets using the look-through approach**

**99.116** Consider a fund that replicates an equity index. Moreover, assume the following:

- (1) The bank uses the Standardised Approach for credit risk when calculating its capital requirements for credit risk and for determining counterparty credit risk exposures it uses the SA-CCR.
- (2) The bank owns 20% of the shares of the fund.
- (3) The fund holds forward contracts on listed equities that are cleared through a qualifying CCP (with a notional amount of USD 100); and

(4) The fund presents the following balance sheet:

<b>Assets</b>	
Cash	USD 20
Government bonds (AAA-rated)	USD 30
VM receivable (ie collateral posted by the bank to the CCP in respect of the forward contracts)	USD 50
<b>Liabilities</b>	
Notes payable	USD 5
<b>Equity</b>	
Shares, retained earnings and other reserves	USD 95

**99.117**The funds exposures will be risk weighted as follows:

- (1) The RWA for the cash ( $RWA_{\text{cash}}$ ) are calculated as the exposure of USD 20 multiplied by the applicable standardised approach (SA) risk weight of 0%. Thus,  $RWA_{\text{cash}} = \text{USD } 0$ .
- (2) The RWA for the government bonds ( $RWA_{\text{bonds}}$ ) are calculated as the exposure of USD 30 multiplied by the applicable SA risk weight of 0%. Thus,  $RWA_{\text{bonds}} = \text{USD } 0$ .
- (3) The RWA for the exposures to the listed equities underlying the forward contracts ( $RWA_{\text{underlying}}$ ) are calculated by multiplying the following three amounts: (1) the SA credit conversion factor of 100% that is applicable to forward purchases; (2) the exposure to the notional of USD 100; and (3) the applicable risk weight for listed equities under the SA which is 100%. Thus,  $RWA_{\text{underlying}} = 100\% * \text{USD}100 * 100\% = \text{USD } 100$ .

(4) The forward purchase equities expose the bank to counterparty credit risk in respect of the market value of the forwards and the collateral posted that is not held by the CCP on a bankruptcy remote basis. For the sake of simplicity, this example assumes the application of SA-CCR results in an exposure value of USD 56. The RWA for counterparty credit risk ( $RWA_{CCR}$ ) are determined by multiplying the exposure amount by the relevant risk weight for trade exposures to CCPs, which 2% in this case (see [CRE54](#) for the capital

requirements for bank exposures to CCPs). Thus,  $RWA_{CCR} = \text{USD } 56 * 2\% = \text{USD } 1.12$ . (Note: There is no credit valuation adjustment, or CVA, charge assessed since the forward contracts are cleared through a CCP.)

**99.118** The total RWA of the fund are therefore  $\text{USD } 101.12 = (0 + 0 + 100 + 1.12)$ .

**99.119** The leverage of a fund under the LTA is calculated as the ratio of the fund's total assets to its total equity, which in this examples is  $100/95$ .

**99.120** Therefore, the RWA for the bank's equity investment in the fund is calculated as the product of the average risk weight of the fund, the fund's leverage and the size of the bank's equity investment. That is:

$$RWA = \frac{RWA_{fund}}{Total\ Assets_{fund}} * Leverage * Equity\ investment = \frac{101.12}{100} * \frac{100}{95} * (95 * 20\%) = \text{USD } 20.2$$

## Calculation of risk-weighted assets using the MBA

**99.121** Consider a fund with assets of USD 100, where it is stated in the mandate that the fund replicates an equity index. In addition to being permitted to invest its assets in either cash or equities, the mandate allows the fund to take long positions in equity index futures up to a maximum nominal amount equivalent to the size of the fund's balance sheet (USD 100). This means that the total on balance sheet and off balance sheet exposures of the fund can reach USD 200. Consider also that a maximum financial leverage (fund assets/fund equity) of 1.1 applies according to the mandate. The bank holds 20% of the shares of the fund, which represents an investment of USD 18.18.

**99.122** First, the on-balance sheet exposures of USD 100 will be risk weighted according to the risk weights applied to equity exposures (risk weight =100%), ie  $RWA_{on-BS} = \text{USD } 100 * 100\% = \text{USD } 100$ .

**99.123** Second, we assume that the fund has exhausted its limit on derivative positions, ie USD 100 notional amount. The RWA for the maximum notional amount of underlying the derivatives positions calculated by multiplying the following three amounts: (1) the SA credit conversion factor of 100% that is applicable to forward purchases; (2) the maximum exposure to the notional of USD 100; and (3) the applicable risk weight for equities under the SA which is 100%. Thus,  $RWA_{\text{underlying}} = 100\% * USD100 * 100\% = USD 100$ .

**99.124** Third, we would calculate the counterparty credit risk associated with the derivative contract. As set out in [CRE60.7\(3\)](#):

- (1) If we do not know the replacement cost related to the futures contract, we would approximate it by the maximum notional amount, ie USD 100.
- (2) If we do not know the aggregate add-on for potential future exposure, we would approximate this by 15% of the maximum notional amount (ie 15% of USD 100=USD 15).
- (3) The counterparty credit risk exposure is calculated by multiplying
  - (a) the sum of the replacement cost and aggregate add-on for potential future exposure; by
  - (b) 1.4, which is the prescribed value of alpha.

**99.125** The counterparty credit risk exposure in this example, assuming the replacement cost and aggregate add-on amounts are unknown, is therefore USD 161 (= 1.4 \* (100+15)). Assuming the futures contract is cleared through a qualifying CCP, a risk weight of 2% applies, so that  $RWA_{\text{CCR}} = USD 161 * 2\% = USD 3.2$ . There is no CVA charge assessed since the futures contract is cleared through a CCP.

**99.126** The RWA of the fund is hence obtained by adding  $RWA_{\text{on-BS}}$ ,  $RWA_{\text{underlying}}$  and  $RWA_{\text{CCR}}$ , ie USD 203.2 (=100 + 100 + 3.2).

**99.127** The RWA (USD 203.2) will be divided by the total assets of the fund (USD 100) resulting in an average risk-weight of 203.2%. The bank's total RWA associated with its equity investment is calculated as the product of the average risk weight of the fund, the fund's maximum leverage and the size of the bank's equity investment. That is the bank's total associated RWA are  $203.2\% * 1.1 * USD 18.18 = USD 40.6$ .



## Calculation of the leverage adjustment

**99.128** Consider a fund with assets of USD 100 that invests in corporate debt. Assume that the fund is highly levered with equity of USD 5 and debt of USD 95. Such a fund would have financial leverage of  $100/5=20$ . Consider the two cases below.

**99.129** In Case 1 the fund specialises in low-rated corporate debt, it has the following balance sheet:

<b>Assets</b>	
Cash	USD 10
A+ to A- bonds	USD 20
BBB+ to BB- bonds	USD 30
Below BB- bonds	USD 40
<b>Liabilities</b>	
Debt	USD 95
<b>Equity</b>	
Shares, retained earnings and other reserves	USD 5

**99.130** The average risk weight of the fund is  $(USD10*0\% + USD20*50\% + USD30*100\% + USD40*150\%)/USD100 = 100\%$ . The financial leverage of 20 would result in an effective risk weight of 2,000% for banks' investments in this highly levered fund, however, this is capped at a conservative risk weight of 1,250%.

**99.131** In Case 2 the fund specialises in high-rated corporate debt, it has the following balance sheet:

<b>Assets</b>	
Cash	USD 5
AAA to AA- bonds	USD 75
A+ to A- bonds	USD 20
<b>Liabilities</b>	
Debt	USD 95
<b>Equity</b>	
Shares, retained earnings and other reserves	USD 5

**99.132** The average risk weight of the fund is  $(USD5 \cdot 0\% + USD75 \cdot 20\% + USD20 \cdot 50\%) / USD100 = 25\%$ . The financial leverage of 20 results in an effective risk weight of 500%.

**99.133** The above examples illustrate that the rate at which the 1,250% cap is reached depends on the underlying riskiness of the portfolio (as judged by the average risk weight) as captured by standardised approach risk weights or the IRB approach. For example, for a "risky" portfolio (100% average risk weight), the 1,250% limit is reached fairly quickly with a leverage of 12.5x, while for a "low risk" portfolio (25% average risk weight) this limit is reached at a leverage of 50x.