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February 8, 2008

Mr. David Stawick
Office of the Secretariat
Commodity Futures Trading Commission
Three Lafayette Centre
1155 21st Street, NW
Washington, DC 20581

RE: Changes to Allow Volatility Quoting Convention on CME Globex® for Selected American- and European-Style Options on Foreign Exchange Futures Contracts.
CME Submission 08-28

Dear Mr. Stawick:

Chicago Mercantile Exchange Inc. ("CME") hereby notifies the Commission that it is adopting rule changes to allow selected CME American- and European-Style Options on FX (Foreign Exchange) Futures contracts to be quoted and traded in volatility terms in addition to the current method of quoting and trading in premium terms. Implementation is targeted for first quarter 2008. CME will notify the Commission under separate cover as to the specific effective date for volatility quoting and trading. The initial FX products selected for volatility quoting are: (1) Options on British Pound Futures (both American- and European-style exercise), (2) Options on Canadian Dollar Futures (both American- and European-style exercise), (3) Options on Euro Futures (both American- and European-style exercise), (4) Options on Japanese Yen Futures (both American- and European-style exercise), (5) Options on Swiss Franc Futures (both American- and European-style exercise) and (6) Options on Australian Dollar Futures (American-style exercise only). Please note that CME currently does not list European-style exercise Options on Australian Dollar Futures contracts.

The following bullet points summarize this initiative:

- The volatility-quoted instruments will initially be quoted and traded separately from premium-quoted products.
- Volatility-quoting will be available on six major American- and five European-style FX instruments currently listed on CME Globex®.
- In addition to quoting single product type, volatility-quoting will be available for the following spreads using single volatility bid and offer inputs: straddles, strangles and verticals.
- Matching of volatility prices will occur on a FIFO basis, with minimum price fluctuations of 0.025%. A refined tick pricing granularity (1/10th regular premium tick, 1/5th for British pound) will insure accuracy of the volatility-to-premium conversion.

- When a trade occurs, the volatility match will be reported, but customer accounts will only receive the individual option legs and associated futures hedge breakdown.
- The pricing engine will convert volatility matches using the Black model for European-style options and the Whaley (over Black) model for American-style options. A test sample from each model is available to customers for analysis and testing.
- Once assigned a premium by the CME Globex matching engine, the option leg will be treated and coded as a regular premium-quoted option, and thus available for offset through premium-based trading.
- The engine will also allocate a Delta-offsetting futures position to each party in the transaction based on the mid price of the underlying futures contract at the time of the match. This futures allocation will not be reported in Market Data as actual transactions (effect similar to covered transactions).
- Fees will be applied to the option legs only, and CME Group anticipates providing early incentives for market-makers similar to those in place for premium-quoted options.

Please note that the rule amendments to allow for the volatility-quoted options convention were written generically to apply to any product group. CME will include the following notice in the CME Group Special Executive Report on this initiative to define the applicability of the volatility quoted options procedures to the specific FX options products:

> "The CME Group volatility-quoted options convention will be eligible for CME Globex® trading in outright options and straddles, strangles and vertical options spreads for the following contracts: American-style exercise Options on Pound Sterling, Canadian Dollar, Japanese Yen, Euro, Swiss Franc and Australian Dollar Futures; and European-style exercise Options on Pound Sterling, Canadian Dollar, Japanese Yen, Euro and Swiss Franc Futures."

The rule amendments to provide for trading via volatility quoting follow in Appendices 1 and 2 with additions underlined and deletions bracketed and overstruck. "Clean copies" of these same rule amendments follow, respectively, as Appendices 3 and 4. Appendix 5 provides a brief discussion of "what is different" regarding CME Group's current volatility quoted options initiative as opposed to a similar initiative in June 1992.

If you require any additional information, please do not hesitate to contact Mr. Steven Youngren at 312-930-4583 or via e-mail at Steve.Youngren@cmegroup.com or me. Please reference our CME Submission 08-28 on all future correspondence regarding this notification.

Sincerely,

Stephen M. Szarmack
Director and Associate General Counsel

Attachments

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Appendix 1.

Rule Changes to Allow Volatility Quoting and Trading in Six Selected American-Style and the Five European-Style FX Options on Futures Contracts. The rule amendments follow with additions underlined and deletions bracketed and overstruck.

251A01. OPTION CHARACTERISTICS

251A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per pound sterling. Each $0.0001 per pound sterling (one point) shall represent $6.25. For example, a quote of .0070 represents an option price of $437.50 (70 points x $6.25 per point) of premium. The minimum fluctuation shall be one point (also known as one tick).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex® converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00002 per pound sterling (equal to $1.25).

Remainder of rules is unchanged.

252A01. OPTION CHARACTERISTICS

252A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Canadian dollar. Each $0.0001 per Canadian dollar (one point) shall represent $10.00. For example, a quote of .0075 represents an option price of $750.00 (75 points x $10.00 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($5, also known as one-half tick), $.00015 ($15, also known as one and one-half ticks), $.00025 ($25, also known as two and one-half ticks), $.00035 ($35, also known as three and one-half ticks), and $.00045 ($45, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00001 per Canadian dollar (equal to $1.00).

Remainder of rules is unchanged.

253A01. OPTION CHARACTERISTICS

253A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Japanese yen. Each $0.000001 per Japanese yen (one point) shall represent $12.50. For example, a quote of .000075 represents an option price of $937.50 (75 points x $12.50 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.0000005 ($6.25, also known as one-half tick), $.0000015 ($18.75, also known as one and one-half ticks), $.0000025 ($31.25, also known as two and one-half ticks), $.0000035 ($43.75, also known as three and one-half ticks), and $.0000045 ($56.25, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price

increment for the premium-based option position shall be $0.0000001 per Japanese yen (equal to $1.25).

Remainder of rules is unchanged.

254A01. OPTION CHARACTERISTICS

254A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Swiss franc. Each $0.0001 per Swiss franc (one point) shall represent $12.50. For example, a quote of .0075 represents an option price of $937.50 (75 points x $12.50 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($6.25, also known as one-half tick), $.00015 ($18.75, also known as one and one-half ticks), $.00025 ($31.25, also known as two and one-half ticks), $.00035 ($43.75, also known as three and one-half ticks), and $.00045 ($56.25, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00001 per Swiss franc (equal to $1.25).

Remainder of rules is unchanged.

255A01. OPTION CHARACTERISTICS

255A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Australian dollar. Each $0.0001 per Australian dollar (one point) shall represent $10.00. For example, a quote of .0075 represents an option price of $750.00 (75 points x $10.00 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($5, also known as one-half tick), $.00015 ($15, also known as one and one-half ticks), $.00025 ($25, also known as two and one-half ticks), $.00035 ($35, also known as three and one-half ticks), and $.00045 ($45, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00001 per Australian dollar (equal to $1.00).

Remainder of rules is unchanged.

261A01. OPTION CHARACTERISTICS

261A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Euro. Each $0.0001 per Euro (one point) shall represent $12.50. For example, a quote of .0075 represents an option price of $937.50 (75 points x $12.50 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($6.25, also known as one-half tick), $.00015 ($18.75, also known as one and one-half ticks), $.00025 ($31.25, also known as two and one-half ticks), $.00035 ($43.75, also known as three and one-half ticks), and $.00045 ($56.25, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the

volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00001 per Euro (equal to $1.25).

Remainder of rules is unchanged.

Appendix 2.

New Rule 584 – CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING and Its Interpretation to Allow for Volatility Quoting and Trading in Selected CME Group Options on Futures Products Traded on CME Globex. The rule amendments follow with additions underlined and deletions bracketed and overstruck.

584. ~~[RESERVED]~~ CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING.

For contracts deemed eligible by the exchange, CME Globex provides for quoting and trading of outright options and options strategies (*e.g.*, options combinations such as straddles, strangles, verticals, and any other options strategies deemed approved by the exchange) in terms of volatility quotes in addition to premium quotes. Any outright option or option strategy so traded will be designated as a single instrument on the CME Globex system. Any outright option or options strategy may trade simultaneously as separate instruments on CME Globex using volatility quotes and premium quotes.

The options volatility quoting convention allows for bids and offers in terms of annualized implied volatility (*e.g.*, 12.450% bid at 12.550% offer).

Volatility quoted option trades shall be matched at the option instrument level according to the first priority for best price and FIFO matching algorithm described in Rule 580 – **GLOBEX TRADE ALGORITHMS** and its Interpretation. Further, volatility quoted option bids shall be matched only with volatility quoted option offers (premium quoted options will not be matched with volatility quoted options). At the time of an options volatility match, CME Globex will utilize standard options pricing models to convert the options volatility trade into a premium quoted option for clearing, and where applicable, create accompanying risk reducing futures contracts as a delta-neutral hedge for the matched position.

For more details concerning volatility options quotes and trading, see the individual options contract Price Increments rules in applicable product chapters and the "Interpretations & Special Notices Relating to Chapter 5" at the end of Chapter 5.

INTERPRETATIONS & SPECIAL NOTICES RELATING TO CHAPTER 5

INTERPRETATION OF RULE 584.—CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING

CME GLOBEX OPTIONS VOLATILITY TRADING MATCH. Once a trade occurs in an outright option or combination quoted in volatility terms, this matched transaction will be assigned: (1) a price in premium terms for each option in the trade and (2) a delta-neutral hedge quantity assignment of futures contracts, if applicable, according to the following procedures:

1. The exchange will determine the option price in premium terms by inserting the following variables into the appropriate standard option pricing model:

   (a) matched implied volatility,
   (b) underlying futures price from CME Globex (see details below),
   (c) time to expiration in years (equals number of calendar days from option's trade date to option's expiration date divided by 365 days),
   (d) option strike price,
   (e) current interest rate (see details below),
   (f) whether a put or a call option,
   (g) option style, either European or American to determine the appropriate standard option pricing model as detailed in Appendix A.

   The resulting premium price will be rounded to the appropriate minimum tick interval of the option according to the individual options' Price Increments rules.

Where, the interest rate used will be the rate implied by the prior day's settlement price of the nearest to expiration CME Group serial or quarterly Three-Month Eurodollar futures contract month (100.00 – 3-Month Eurodollar futures price = interest rate).

Where, the underlying futures price used will be based on the following tiered hierarchy:

Tier 1: Most recent **midpoint** of the nearest to expiration March quarterly cycle ("front month") futures contract bid and ask spread on CME Globex is used as the basis for determining the underlying futures prices for all listed contract months.

a. If the calculated midpoint is not on-a-tick, CME Globex will round to either the bid side or ask side whichever has the smallest quantity of contracts bid or offered.
b. If the volatility quoted option being matched has an underlying futures contract other than the front month futures contract, then CME Globex will adjust the calculated price for the front month futures contract by the appropriate previous day's settlement price spread differential to imply an appropriate underlying futures price.
c. Normally, under Tier 1, the underlying futures price is based on the front-month future bid/ask spread. However, during the expiration week of the front month future, CME Globex compares the bid/ask spreads of the front month future and the next quarterly contract month and uses the instrument with the tightest bid/ask spread for the volatility to premium price conversion. However, if the next quarterly contract month bid/ask spread is used (tighter bid/ask spread), then CME Globex will imply the underlying futures price for the front month future from the next quarterly contract month midpoint, adjusted by the appropriate spread differential from the respective previous day's settlement prices.

Tier 2: **Previous settlement price** (when no most recent bid/ask midpoint in the nearest to expiration March quarterly cycle futures contract is available).

2. When the outright option includes futures in a delta neutral ratio to the options, the delta will be calculated for European-style options from the standard Black option pricing model, and for the American-style options from the standard Whaley option pricing model. See Appendix A for details of these standard options pricing models.

3. The quantity ("Q_{fut}") of futures contracts to be allocated in the delta-neutral hedge equals the product of the net delta in the options combination ("Δ") as determined by the applicable options pricing model, and the quantity of trades ("Q_{opt}") triggered by the incoming options order. This resulting product is rounded to the nearest integer to determine the quantity of futures contracts allocated.

$$Q_{fut} = \Delta * Q_{opt}$$

In the event an incoming options order trading in volatility terms is matched by CME Globex to more than one resting order, the resulting allocation of futures contracts shall be as follows:

The incoming order is matched via the best price and FIFO matching algorithm to two or more resting orders. The quantity of each such allocation of futures contracts equals the quantity of that portion of the matched options trade times the net delta, rounded down to the nearest integer. The sum total of the futures contracts allocated to the resting options orders after this allocation may be less than the allocation of futures contracts originally defined for the incoming options order. This difference shall be allocated one futures contract at a time to the resting order portion that is the most under allocated (*i.e.*, highest remainder given the product of the net delta and option order quantity), based on the extent of rounding down in the calculation above. If there is a tie in the amounts by which two or more resting orders are the most under allocated, then the residual futures
contract shall be allocated to the oldest resting order (first order entered) that is matched to the incoming options order.

If the incoming options order is for a quantity larger than can be matched with resting orders at the same options volatility price, then the remaining quantity of the incoming options order becomes a resting limit order for the unmatched, remaining quantity at the same volatility price.

The price of futures contracts allocated by CME Globex shall be as determined in step 1 above. The following section provides a numerical example of CME Globex allocations of futures contracts, given a volatility-quoted option match.

Match of Multiple Counterparties and Futures Contract Hedge Assignments

The following example is for a European-style option:

Assume the Ask side order enters the market and sweeps the Bid side quantity in resting orders.

1.7000 Call / Currency Option			
	BID	ASK	
QTY	Volatility	Volatility	QTY
40	1220	1220	100 (incoming order)
30	1220		
20	1220		
10	1220		

The Black option pricing model outputs a computed net delta of 0.51.

The Bid side breakdown for assigned futures contracts is as follows:

Bid Side QTY	Delta	Delta x QTY	Rounding Down	Residual	Total Assigned Futures Contracts
40	0.51	20.4	20	1*	21
30	0.51	15.3	15	0	15
20	0.51	10.2	10	0	10
10	0.51	5.1	5	0	5
Subtotals			50	1	51
100 matched to incoming order	0.51	Totals 51	51	Na	51

* Remainder amount rounded down for this order = 0.40, which is the highest amount of all orders. Therefore, this order is the most under allocated and is allocated the residual futures contract.

Appendix A: Option Pricing Models

For the purposes of providing conversions of volatility to premium option prices and options deltas under Rule 584, CME Globex will use the following option pricing models for European- and American-style options.

Black Option Pricing Model for European-Style Options

CME Assumptions

- Applicable interest rate will be based on the nearest to expiration Eurodollar Time Deposit (ED) future contract month
- Price of the underlying futures contract from CME Globex as determined by the methodology detailed in this Interpretation
- Time to expiration in years is $\frac{\#\,of\,days}{365}$

Abbreviations used in the formula

C = call premium
P = put premium
U = price of the underlying contract (future)
E = expiration (strike) price
t = time to expiration in years
v = annual volatility expressed as a decimal
r = interest rate assumption expressed in decimal
e = base of the natural logarithm
ln = natural logarithm
N = normal standard distribution
h = calculated variable (see formula below)

Equations*

$$C = Ue^{-rt}\mathrm{N}(h) - Ee^{-rt}\mathrm{N}(h - v\sqrt{t})$$

$$P = -Ue^{-rt}\mathrm{N}(-h) + Ee^{-rt}\mathrm{N}(v\sqrt{t} - h)$$

$$\textit{Where}\ h = \frac{\ln\left(\frac{U}{E}\right) + \frac{v^2}{2}t}{v\sqrt{t}}$$

$$\textit{Call delta} = e^{-rt}\mathrm{N}(h)$$

$$\textit{Put delta} = -e^{-rt}\mathrm{N}(-h)$$

*Natenberg, S. (1994). *Option Volatility and Pricing.* New York: McGraw-Hill

Whaley Option Pricing Model for American-Style Options

The following model is based on the Barone-Adesi-Whaley model as described in the Journal of Finance, Vol. 42 No.2, pages 301-320. The model uses analytic approximation techniques to solve for the price of the American-style option. The model estimates a value for S* which is the underlying price above which the option should be exercised. The value of S* is then used to determine the value of the option. For call options, the model estimates S* by satisfying the following equation:

(LHS – RHS / K < 0.00001 (Please see notes 1-4 at the end of this section.)

Where

$LHS = S^* - K$

$RHS = e^{(b-r)T}[S^* N(d_1) - KN(d_2)] + [(1 - e^{(b-r)T} N(d_1)) * (S^*/q_2)]$

$d_1 = [\ln(S^*/K) + (b + \sigma^2/2)T] / \sigma\sqrt{T}$

$d_2 = d_1 - \sigma\sqrt{T}$

$q_2 = [-(N-1) + \sqrt{(N-1)^2 + 4M/k}\ ] / 2$

$M = 2 * r / \sigma^2$

$N = 2 * b / \sigma^2$

$k = 1 - e^{-rT}$

N(.) is the cumulative univariate normal distribution.

n(.) is the univariate normal density function.

E = volatility (e.g. 10% per annum = 0.10)

T = time until expiration in years (e.g. 90 days = 0.247)

r = interest rate (e.g. 8% per annum = 0.08)

b = cost of carry, assumed to be zero for the purposes of this calculation

K = strike price

S = underlying price

After each iteration, the estimate of S^* is adjusted by:

$$S^*_{i+1} = [K + RHS - b_i S^*_i] / (1 - b_i)$$

where

$$b_i = e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_2) + [1 - e^{(b-r)T} n[d_1(S^*_i)] / \sigma \sqrt{T}] / q_2$$

Once the correct value of S^* is found, the value of the call and the call's delta are found by solving:

$$C(S,T) = C(S,T) + A_2 (S / S^*)^{q_2}$$

Where

$$A_2 = (S^* / q_2) (1 - e^{b-r)T} N[d_1(S^*)])$$

$$\Delta = \Delta_e + A_2 * q_2 * (S / S^*)^{q_2} / S$$

$c(S,T)$ = the price of a European style call option.

Δ_e = the delta of the European style call option.

For put options, the model estimates S^* by satisfying:

$$(LHS - RHS) / K < 0.00001$$

where

$$LHS = K - S^*$$

$$RHS = e^{(b-r)T}[KN(d_2) - S^* N(d_1)] - [(1 - e^{(b-r)T} N(d_1)) * (S^* / q_1)]$$

$$d_1 = [\ln(S^* / K) + (b + \sigma^2/2)T] / \sigma \sqrt{T}$$

$$d_2 = d_1 + \sigma \sqrt{T}$$

$$q_1 = [-(N-1) - \sqrt{(N-1)^2 + 4M / k}] / 2$$

$$M = 2 * r / \sigma^2$$

$$N = 2 * b / \sigma^2$$

$$k = 1 - e^{-rT}$$

$N(.)$ is the cumulative univariate normal distribution.

$n(.)$ is the univariate normal density function.

σ = volatility (e.g. 10% per annum = 0.10)

T = time until expiration in years (e.g. 90 days = 0.247)

r = interest rate (e.g. 8% per annum = 0.08)

b = cost of carry, assumed to be zero for the purposes of this calculation

K = strike price

S = underlying price

After each iteration, the estimate of S is adjusted by:*

$$S^*_{i+1} = [\, K + RHS - b_i S^*_i \,] / (1 - b_i)$$

where

$$b_1 = e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_1) + [1 - e^{(b-r)T} n[d_1(S^*_i)] / \sigma \sqrt{T}\,] / q_1$$

Once the correct value of S is found, the value of the put and the put's delta are found by solving:*

$$P(S,T) = p(S,T) + A_1 (S / S^*)^{q_1}$$

where

$$A_1 = -(S^* / q_1)(1 - e^{(b-r)T} N[d_1(S^*)])$$

$$\Delta = \Delta_e + A_1 * q_1 * (S / S^*)^{q_1} / S$$

p(S,T) = the price of a European style put option.

Δ_e *= the delta of the European style put option.*

Note 1. CME Group's Falcon engine goes slightly further in its precision to 0.000001 (one more decimal place).

Note 2. CME Group's Falcon engine also has a maximum number of iterations that it will perform on the equation discussed in Note 1 to fall within the tolerance level. If after 10,000 iterations the Falcon engine calculation is not within a tolerance of 0.000001, it will fall back to the European model instead.

Note 3. CME Group's Falcon engine does not implement any notion of a carrying-cost or foreign interest rate. The *b* variable is always equal to zero in the equations. If for some reason the Falcon engine does start to use *b*, it is worth noting that if *b* is ever greater than or equal to the interest rate *r*, the Falcon engine automatically falls back to the European model.

Note 4. CME Group's Falcon engine uses the Black Option Pricing Model (see Appendix A) in place of the Merton Model referred to in the abstract of Giovanni Barone-Adesi and Robert E. Whaley's article in the June 1987 *Journal of Finance* (Volume XLII, No. 2).

End of Interpretation to Rule 584.

Appendix 3.

Clean Copy Incorporating Rule Changes to Allow Volatility Quoting and Trading in Six Selected American-Style and the Five European-Style FX Options on Futures Contracts.

251A01. OPTION CHARACTERISTICS

251A01.C. Price Increments

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If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex® converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00002 per pound sterling (equal to $1.25).

Remainder of rules is unchanged.

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The price of an option shall be quoted in U.S. dollars per Canadian dollar. Each $0.0001 per Canadian dollar (one point) shall represent $10.00. For example, a quote of .0075 represents an option price of $750.00 (75 points x $10.00 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($5, also known as one-half tick), $.00015 ($15, also known as one and one-half ticks), $.00025 ($25, also known as two and one-half ticks), $.00035 ($35, also known as three and one-half ticks), and $.00045 ($45, also known as four and one-half ticks).

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If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.0000001 per Japanese yen (equal to $1.25).

Remainder of rules is unchanged.

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The price of an option shall be quoted in U.S. dollars per Swiss franc. Each $0.0001 per Swiss franc (one point) shall represent $12.50. For example, a quote of .0075 represents an option price of $937.50 (75 points x $12.50 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($6.25, also known as one-half tick), $.00015 ($18.75, also known as one and one-half ticks), $.00025 ($31.25, also known as two and one-half ticks), $.00035 ($43.75, also known as three and one-half ticks), and $.00045 ($56.25, also known as four and one-half ticks).

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Remainder of rules is unchanged.

255A01. OPTION CHARACTERISTICS

255A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Australian dollar. Each $0.0001 per Australian dollar (one point) shall represent $10.00. For example, a quote of .0075 represents an option price of $750.00 (75 points x $10.00 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($5, also known as one-half tick), $.00015 ($15, also known as one and one-half ticks), $.00025 ($25, also known as two and one-half ticks), $.00035 ($35, also known as three and one-half ticks), and $.00045 ($45, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00001 per Australian dollar (equal to $1.00).

Remainder of rules is unchanged.

261A01. OPTION CHARACTERISTICS

261A01.C. Price Increments

The price of an option shall be quoted in U.S. dollars per Euro. Each $0.0001 per Euro (one point) shall represent $12.50. For example, a quote of .0075 represents an option price of $937.50 (75 points x $12.50 per point) of premium. The minimum fluctuation shall be one point (also known as one tick). A trade may also occur at a price of $.00005 ($6.25, also known as one-half tick), $.00015 ($18.75, also known as one and one-half ticks), $.00025 ($31.25, also known as two and one-half ticks), $.00035 ($43.75, also known as three and one-half ticks), and $.00045 ($56.25, also known as four and one-half ticks).

If options are quoted in volatility terms pursuant to Rule 584, the minimum fluctuation shall be 0.025 percent for the volatility quote. Also, following a volatility trade, when CME Globex converts the volatility-traded options position into a premium-based options position for clearing, the minimum price increment for the premium-based option position shall be $0.00001 per Euro (equal to $1.25).

Remainder of rules is unchanged.

Appendix 4.

Clean Copy of Approved Changes to New Rule 584 – CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING and Its Interpretation to Allow for Volatility Quoting and Trading in Selected CME Group Options on Futures Products Traded on CME Globex.

584. CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING.

For contracts deemed eligible by the exchange, CME Globex provides for quoting and trading of outright options and options strategies (*e.g.*, options combinations such as straddles, strangles, verticals, and any other options strategies deemed approved by the exchange) in terms of volatility quotes in addition to premium quotes. Any outright option or option strategy so traded will be designated as a single instrument on the CME Globex system. Any outright option or options strategy may trade simultaneously as separate instruments on CME Globex using volatility quotes and premium quotes.

The options volatility quoting convention allows for bids and offers in terms of annualized implied volatility (*e.g.*, 12.450% bid at 12.550% offer).

Volatility quoted option trades shall be matched at the option instrument level according to the first priority for best price and FIFO matching algorithm described in Rule 580 – **GLOBEX TRADE ALGORITHMS** and its Interpretation. Further, volatility quoted option bids shall be matched only with volatility quoted option offers (premium quoted options will not be matched with volatility quoted options). At the time of an options volatility match, CME Globex will utilize standard options pricing models to convert the options volatility trade into a premium quoted option for clearing, and where applicable, create accompanying risk reducing futures contracts as a delta-neutral hedge for the matched position.

For more details concerning volatility options quotes and trading, see the individual options contract Price Increments rules in applicable product chapters and the "Interpretations & Special Notices Relating to Chapter 5" at the end of Chapter 5.

INTERPRETATIONS & SPECIAL NOTICES RELATING TO CHAPTER 5

INTERPRETATION OF RULE 584.—CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING

CME GLOBEX OPTIONS VOLATILITY TRADING MATCH. Once a trade occurs in an outright option or combination quoted in volatility terms, this matched transaction will be assigned: (1) a price in premium terms for each option in the trade and (2) a delta-neutral hedge quantity assignment of futures contracts, if applicable, according to the following procedures:

1. The exchange will determine the option price in premium terms by inserting the following variables into the appropriate standard option pricing model:

   (a) matched implied volatility,
   (b) underlying futures price from CME Globex (see details below),
   (c) time to expiration in years (equals number of calendar days from option's trade date to option's expiration date divided by 365 days),
   (d) option strike price,
   (e) current interest rate (see details below),
   (f) whether a put or a call option,
   (g) option style, either European or American to determine the appropriate standard option pricing model as detailed in Appendix A.

   The resulting premium price will be rounded to the appropriate minimum tick interval of the option according to the individual options' Price Increments rules.

Where, the interest rate used will be the rate implied by the prior day's settlement price of the nearest to expiration CME Group serial or quarterly Three-Month Eurodollar futures contract month (100.00 – 3-Month Eurodollar futures price = interest rate).

Where, the underlying futures price used will be based on the following tiered hierarchy:

Tier 1: Most recent **midpoint** of the nearest to expiration March quarterly cycle ("front month") futures contract bid and ask spread on CME Globex is used as the basis for determining the underlying futures prices for all listed contract months.
   a. If the calculated midpoint is not on-a-tick, CME Globex will round to either the bid side or ask side whichever has the smallest quantity of contracts bid or offered.
   b. If the volatility quoted option being matched has an underlying futures contract other than the front month futures contract, then CME Globex will adjust the calculated price for the front month futures contract by the appropriate previous day's settlement price spread differential to imply an appropriate underlying futures price.
   c. Normally, under Tier 1, the underlying futures price is based on the front-month future bid/ask spread. However, during the expiration week of the front month future, CME Globex compares the bid/ask spreads of the front month future and the next quarterly contract month and uses the instrument with the tightest bid/ask spread for the volatility to premium price conversion. However, if the next quarterly contract month bid/ask spread is used (tighter bid/ask spread), then CME Globex will imply the underlying futures price for the front month future from the next quarterly contract month midpoint, adjusted by the appropriate spread differential from the respective previous day's settlement prices.

Tier 2: **Previous settlement price** (when no most recent bid/ask midpoint in the nearest to expiration March quarterly cycle futures contract is available).

2. When the outright option includes futures in a delta neutral ratio to the options, the delta will be calculated for European-style options from the standard Black option pricing model, and for the American-style options from the standard Whaley option pricing model. See Appendix A for details of these standard options pricing models.

3. The quantity ("Q_{fut}") of futures contracts to be allocated in the delta-neutral hedge equals the product of the net delta in the options combination ("Δ") as determined by the applicable options pricing model, and the quantity of trades ("Q_{opt}") triggered by the incoming options order. This resulting product is rounded to the nearest integer to determine the quantity of futures contracts allocated.

$$Q_{fut} = \Delta * Q_{opt}$$

In the event an incoming options order trading in volatility terms is matched by CME Globex to more than one resting order, the resulting allocation of futures contracts shall be as follows:

The incoming order is matched via the best price and FIFO matching algorithm to two or more resting orders. The quantity of each such allocation of futures contracts equals the quantity of that portion of the matched options trade times the net delta, rounded down to the nearest integer. The sum total of the futures contracts allocated to the resting options orders after this allocation may be less than the allocation of futures contracts originally defined for the incoming options order. This difference shall be allocated one futures contract at a time to the resting order portion that is the most under allocated (*i.e.*, highest remainder given the product of the net delta and option order quantity), based on the extent of rounding down in the calculation above. If there is a tie in the amounts by which two or more resting orders are the most under allocated, then the residual futures
contract shall be allocated to the oldest resting order (first order entered) that is matched to the incoming options order.

If the incoming options order is for a quantity larger than can be matched with resting orders at the same options volatility price, then the remaining quantity of the incoming options order becomes a resting limit order for the unmatched, remaining quantity at the same volatility price.

The price of futures contracts allocated by CME Globex shall be as determined in step 1 above. The following section provides a numerical example of CME Globex allocations of futures contracts, given a volatility-quoted option match.

Match of Multiple Counterparties and Futures Contract Hedge Assignments

The following example is for a European-style option:

Assume the Ask side order enters the market and sweeps the Bid side quantity in resting orders.

1.7000 Call / Currency Option			
	BID	ASK	
QTY	Volatility	Volatility	QTY
40	1220	1220	100 (incoming order)
30	1220		
20	1220		
10	1220		

The Black option pricing model outputs a computed net delta of 0.51.

The Bid side breakdown for assigned futures contracts is as follows:

Bid Side QTY	Delta	Delta x QTY	Rounding Down	Residual	Total Assigned Futures Contracts
40	0.51	20.4	20	1*	21
30	0.51	15.3	15	0	15
20	0.51	10.2	10	0	10
10	0.51	5.1	5	0	5
Subtotals			50	1	51
100 matched to incoming order	0.51	Totals 51	51	Na	51

* Remainder amount rounded down for this order = 0.40, which is the highest amount of all orders. Therefore, this order is the most under allocated and is allocated the residual futures contract.

Appendix A: Option Pricing Models

For the purposes of providing conversions of volatility to premium option prices and options deltas under Rule 584, CME Globex will use the following option pricing models for European- and American-style options.

Black Option Pricing Model for European-Style Options

CME Assumptions

- Applicable interest rate will be based on the nearest to expiration Eurodollar Time Deposit (ED) future contract month
- Price of the underlying futures contract from CME Globex as determined by the methodology detailed in this Interpretation
- Time to expiration in years is $\frac{\#ofdays}{365}$

Abbreviations used in the formula

C = call premium
P = put premium
U = price of the underlying contract (future)
E = expiration (strike) price
t = time to expiration in years
v = annual volatility expressed as a decimal
r = interest rate assumption expressed in decimal
e = base of the natural logarithm
ln = natural logarithm
N = normal standard distribution
h = calculated variable (see formula below)

Equations*

$$C = Ue^{-rt}\mathrm{N}(h) - Ee^{-rt}\mathrm{N}(h - v\sqrt{t})$$

$$P = -Ue^{-rt}\mathrm{N}(-h) + Ee^{-rt}\mathrm{N}(v\sqrt{t} - h)$$

$$\textit{Where}\quad h = \frac{\ln\left(\frac{U}{E}\right) + \frac{v^2}{2}t}{v\sqrt{t}}$$

$$\textit{Call delta} = e^{-rt}\mathrm{N}(h)$$

$$\textit{Put delta} = -e^{-rt}\mathrm{N}(-h)$$

*Natenberg, S. (1994). *Option Volatility and Pricing.* New York: McGraw-Hill

Whaley Option Pricing Model for American-Style Options

The following model is based on the Barone-Adesi-Whaley model as described in the Journal of Finance, Vol. 42 No.2, pages 301-320. The model uses analytic approximation techniques to solve for the price of the American-style option. The model estimates a value for S* which is the underlying price above which the option should be exercised. The value of S* is then used to determine the value of the option. For call options, the model estimates S* by satisfying the following equation:

$(LHS - RHS / K < 0.00001$ (Please see notes 1-4 at the end of this section.)

Where

$LHS = S^* - K$

$RHS = e^{(b-r)T}[S^* N(d_1) - KN(d_2)] + [(1 - e^{(b-r)T} N(d_1)) * (S^* / q_2)]$

$d_1 = [ln(S^*/K) + (b + \sigma^2/2)T] / \sigma\sqrt{T}$

$d_2 = d_1 - \sigma\sqrt{T}$

$q_2 = [-(N-1) + \sqrt{(N-1)^2 + 4M/k}\ ] / 2$

$M = 2 * r / \sigma^2$

$N = 2 * b / \sigma^2$

$k = 1 - e^{-rT}$

N(.) is the cumulative univariate normal distribution.

n(.) is the univariate normal density function.

σ = volatility (e.g. 10% per annum = 0.10)

T = time until expiration in years (e.g. 90 days = 0.247)

r = interest rate (e.g. 8% per annum = 0.08)

b = cost of carry, assumed to be zero for the purposes of this calculation

K = strike price

S = *underlying price*

After each iteration, the estimate of S is adjusted by:*

$$S^*_{i+1} = [\, K + RHS - b_i S^*_i \,] / (1 - b_i)$$

where

$$b_i = e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_2) + [1 - e^{(b-r)T} n[d_1(S^*_i)] / \sigma \sqrt{T}\,] / q_2$$

Once the correct value of S is found, the value of the call and the call's delta are found by solving:*

$$C(S,T) = C(S,T) + A_2 (S / S^*)^{q_2}$$

Where

$$A_2 = (S^* / q_2)\,(1 - e^{b-r)T} N[d_1(S^*)])$$

$$\Delta = \Delta_e + A_2 * q_2 * (S / S^*)^{q_2} / S$$

$c(S,T)$ = *the price of a European style call option.*

Δ_e = *the delta of the European style call option.*

For put options, the model estimates S by satisfying:*

$$(LHS - RHS) / K < 0.00001$$

where

$$LHS = K - S^*$$

$$RHS = e^{(b-r)T}[KN(d_2) - S^* N(d_1)] - [(1 - e^{(b-r)T} N(d_1)) * (S^* / q_1)]$$

$$d_1 = [\ln(S^* / K) + (b + \sigma^2/2)T] / \sigma \sqrt{T}$$

$$d_2 = d_1 + \sigma \sqrt{T}$$

$$q_1 = [-(N-1) - \sqrt{(N-1)^2 + 4M / k}\,] / 2$$

$$M = 2 * r / \sigma^2$$

$$N = 2 * b / \sigma^2$$

$$k = 1 - e^{-rT}$$

$N(.)$ *is the cumulative univariate normal distribution.*

$n(.)$ *is the univariate normal density function.*

σ = *volatility (e.g. 10% per annum = 0.10)*

T = *time until expiration in years (e.g. 90 days = 0.247)*

r = *interest rate (e.g. 8% per annum = 0.08)*

b = *cost of carry, assumed to be zero for the purposes of this calculation*

K = *strike price*

S = *underlying price*

After each iteration, the estimate of S is adjusted by:*

$$S^*_{i+1} = [\, K + RHS - b_i S^*_i \,] / (1 - b_i)$$

where

$$b_i = e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_1) + [1 - e^{(b-r)T} n[d_1(S^*_i)] / \sigma \sqrt{T}\,] / q_1$$

Once the correct value of S is found, the value of the put and the put's delta are found by solving:*

$$P(S,T) = p(S,T) + A_1 (S / S^*)^{q_1}$$

where

$$A_1 = -(S^* / q_1)(1 - e^{(b-r)T} N[d_1(S^*)])$$

$$\Delta = \Delta_e + A_1 * q_1 * (S / S^*)^{q_1} / S$$

$p(S,T)$ = *the price of a European style put option.*

Δ_e = *the delta of the European style put option.*

Note 1. CME Group's Falcon engine goes slightly further in its precision to 0.000001 (one more decimal place).

Note 2. CME Group's Falcon engine also has a maximum number of iterations that it will perform on the equation discussed in Note 1 to fall within the tolerance level. If after 10,000 iterations the Falcon engine calculation is not within a tolerance of 0.000001, it will fall back to the European model instead.

Note 3. CME Group's Falcon engine does not implement any notion of a carrying-cost or foreign interest rate. The *b* variable is always equal to zero in the equations. If for some reason the Falcon engine does start to use *b*, it is worth noting that if *b* is ever greater than or equal to the interest rate *r*, the Falcon engine automatically falls back to the European model.

Note 4. CME Group's Falcon engine uses the Black Option Pricing Model (see Appendix A) in place of the Merton Model referred to in the abstract of Giovanni Barone-Adesi and Robert E. Whaley's article in the June 1987 *Journal of Finance* (Volume XLII, No. 2).

End of Interpretation to Rule 584.

Appendix 5.

CME Group's 2008 vs. 1992 Volatility Quoted Options Projects

In June 1992, the Commodity Futures Trading Commission (CFTC) approved rule amendments to allow Chicago Mercantile Exchange Inc. (CME) volatility-quoted options trading on its GLOBEX® electronic trading system. CFTC staff has inquired as to what are the significant differences between the volatility quoting options trading project then as opposed to now. A brief summary follows:

Applicable Products:	**2008** - American-style exercise Options on Pound Sterling, Canadian Dollar, Japanese Yen, Euro, Swiss Franc and Australian Dollar Futures; and European-style exercise Options on Pound Sterling, Canadian Dollar, Japanese Yen, Euro and Swiss Franc Futures. **1992** – American-style exercise Options on Pound Sterling, Canadian Dollar, Deutsche Mark, Japanese Yen, Swiss Francs, Australian Dollars, British Pound/Deutsche Mark cross-rate, Deutsche Mark/Japanese Yen cross-rate, Deutsche Mark/Swiss Franc cross-rate, Eurodollars and Three-Month U.S. Treasury Bills.
Minimum Volatility Quote:	**2008** – 0.025 percent **1992** – 0.05 percent
Futures Price Used for Appropriate Options Pricing Model:	**2008** – Midpoint of bid and ask of underlying future or the last price or previous settlement price **1992** – Underlying futures contract last trade, or subsequent best bid, if higher or subsequent best offer, if lower
Resulting FX Options Premium From Volatility Trade:	**2008** – Rounded to the nearest 1/10 of a tick (1/5 for BP options) **1992** – Rounded to nearest tick
Option Pricing Models:	**2008** – New volatility-quoted convention applies to European-style options as well as American-style options: Black Options Pricing Model specified for European-style exercise options for determining the premium and deltas Whaley Options Pricing Model specified for American-style exercise options for determining the premium and deltas **1992** – Only American-style options on futures contracts were eligible for volatility-quote trading. Whaley Options Pricing Model only was specified.
Minimum Quantity Restriction:	**2008** – None **1992** – 10 contracts minimum quantity and only multiples of 10 were allowed.
Allocation of Futures Contracts In the Delta Neutral Hedge:	**2008** – Allocation procedure further defined for matching an incoming order with multiple resting orders. **1992** – Allocations to multiple resting orders were not specifically defined.
Marketing Effort:	**2008** – More than one year marketing campaign targeted to attract volatility-quoted options market participants. **1992** – Minimal pre-launch marketing effort.