**Additional VWAP Closing Price methodology blueprint**

## 1 Detailed explanation of the LME's proposed Closing Price pricing methodology

This document provides a detailed explanation of the Additional VWAP Closing Price Methodology, including detailed examples for the front-of-curve ("**FC**") methodology.

### 1.1 FC methodology

The FC methodology is a deterministic approach for pricing the liquid contracts at the front of LME forward curves. It is based on a volume-weighted-average-price ("**VWAP**") calculation of trades during defined pricing windows. The FC framework below has been written in a flexible manner, with the intention that it is scalable and could be applied to additional prompt dates in future if deemed appropriate. Initially it will apply to Cash, M1, M2, M3, M4 in addition to the existing 3-month VWAP for Copper, Aluminium, Nickel, Zinc and Lead.
The approach to price the front of the curve is to:

1. Establish the 3-month price (anchor contract) using a VWAP calculation.
2. Then, in a defined order, price each third Wednesday monthly contract using the spreads[1] between that month and all other contracts that have already been priced. For example, 3M outright first, then establish M3 on the basis of the M3-3M spread, then establish M2 on the basis of both M2-3M and M2-M3 spreads etc.
3. Then price the Cash contract on the basis of the spread between cash and the nearest monthly contract, ie Cash-M1.

The 3-month and spread prices will be established over separate pricing windows for each metal (with the respective spread window immediately preceding the 3-month window) to allow for traders to separately focus on outright trading and spread trading. No outright trades for prompts other than 3-month will be included in the calculation as otherwise the outright prices for the monthly contracts may not align to the 3-month outright price (as they were taken from different pricing windows).

As part of the Additional VWAP Closing Price Methodology, if the volume of the contract being priced does not meet the minimum-volume-requirement (aggregating the input instruments) during the relevant pricing window, then a time-weighted-average-price ("**TWAP**") of a defined "indicator reference price" ("**IRP**") is used. This IRP reflects the last trade (or previous day's Closing Price if there are no trades), dragged higher or lower by a respective better bid or better offer (during the spread pricing window).[2] The IRP will use only one spread which will be the M3-3M spread when pricing M3, then for all other instruments it will be the spread from the instrument to the nearest already priced monthly instrument (e.g for M4 the IRP will use M3-M4, for M2 the IRP will use M2-M3).

The key parameters, and the detail of the calculation of the FC methodology is explained below. For detailed pricing examples please see section 2 of this document.

[1] A calendar spread is often referred to as a "carry" on the LME market.

[2] The TWAP calculation is performed at a millisecond (ms) granularity. Where there are multiple bids, offers or trades in one ms, the TWAP calculation uses the last bid, offer or trade point for that discrete ms.

### 1.1.1 Parameters (FC methodology)

**Anchor contracts:**

| Anchor point | Month |
|---|---|
| **Primary:** | **3-month (3M)** |
| Other: | *None* |

**Spread VWAP Contract order:**

| Ordering | Contract | VWAP Instruments | TWAP Instrument |
|---|---|---|---|
| 1 | 3rd 3rd Wednesday (M3) | M3-3M | M3-3M |
| 2 | 2nd 3rd Wednesday (M2) | M2-3M<br>M2-M3 | M2-M3 |
| 3 | 4th 3rd Wednesday (M4) | M2-M4<br>M3-M4<br>3M-M4 | M3-M4 |
| 4 | 1st 3rd Wednesday (M1) | M1-M2<br>M1-M3<br>M1-3M<br>M1-M4 | M1-M2 |
| 5 | Cash | Cash-M1 | Cash-M1 |

The above table assumes that the 3Mm prompt date falls between M3 and M4 (which is the most common occurrence). Where this is not the case, the same instrument is used, but in its reversed form ie 3M-M3 or M4-3M.

Where the Cash contract is a 3rd Wednesday, then for the purpose of this calculation it will be priced as the Cash contract (with the next contract being M1).

Where the 3-month contract is a 3rd Wednesday, the ordering stays the same but the related “M” contract is already known at the relevant step in the pricing methodology.

**Pricing windows:**

*VWAP Methodology Prompts*

| Metal | Anchor Pricing Window | Spread Pricing Window |
|---|---|---|
| Nickel | 16:15:00:000 – 16:19:59:999 | 16:10:00:000 – 16:14:59:999 |
| Aluminium | 16:25:00:000 – 16:29:59:999 | 16:20:00:000 – 16:24:59:999 |
| Zinc | 16:35:00:000 – 16:39:59:999 | 16:30:00:000 – 16:34:59:999 |
| Copper | 16:45:00:000 – 16:49:59:999 | 16:40:00:000 – 16:44:59:999 |
| Lead | 16:55:00:000 – 16:59:59:999 | 16:50:00:000 – 16:54:59:999 |

*Other non VWAP Methodology prompts*[3]

| Metal(s) | Anchor Pricing Window | Spread Pricing Window |
|---|---|---|
| Cobalt | 15:50:00:000 – 15:54:59:999 | 15:50:00:000 – 15:54:59:999 |
| Aluminium premiums, aluminium alloy and NASAAC | 15:55:00:000 -- 15:59:59:999 | 15:55:00:000 – 15:59:59:999 |
| Tin | 16:05:00:000 – 16:09:59:999 | 16:00:00:000 – 16:04:59:999 |

**Rounding:**

| | Anchor Contract | Spread VWAP Contract |
|---|---|---|
| Aluminium | $0.50/mt | $0.01/mt |
| Copper | $0.50/mt | $0.01/mt |
| Lead | $0.50/mt | $0.01/mt |
| Nickel | $1.00/mt | $0.01/mt |
| Zinc | $0.50/mt | $0.01/mt |

Rounding is performed at the final stage of each prompt level's calculation, and not at individual component spread VWAPs level. The rounded value is used in any subsequent calculations that rely on priced prompts.

**Minimum volume requirements:**
*Additional VWAP Closing Price Methodology*

| | 3m MVR | Spread MVR[4] |
|---|---|---|
| Aluminium | 5 | 5 |
| Copper | 5 | 5 |
| Lead | 5 | 5 |
| Nickel | 5 | 5 |
| Zinc | 5 | 5 |

*Metals not using the Additional VWAP Closing Price methodology*[5]

| | 3m MVR |
|---|---|
| Cobalt | 5 |

[3] 3-month established by VWAP (if MVRs not met, Last Price methodology used). All other prompts valued using existing last price methodology.
[4] The MVR for non-anchor prompts considers all the volume from the spreads that contribute to pricing it
[5] 3-month established by VWAP (if MVRs not met, Last Price methodology used). All other prompts valued using existing last price methodology.

| | |
|---|---|
| Aluminium premiums (M1), aluminium alloy and NASAAC | 5 |
| Tin | 5 |

These minimum volume requirements have been included to allow the methodology to be flexible. The LME believes there is an advantage to having all MVRs set as 5, to avoid situations where very small volumes can impact prices (e.g 2 lots trades at the start of a pricing window). In cases where the MVR is not met, under the Last Price methodology, the LME will determine prices using the Last Price methodology. However, under the Additional VWAP Closing Price methodology, where the MVR is not met, a TWAP shall be used to determine prices.

### 1.1.2 Calculation (FC methodology)

**Anchor Contracts**

Each Anchor Contract is priced based on the following waterfall:

1. If the total volume of trades during the Anchor Pricing Window is equal to or above the Outright MVR, the Closing Price will be the VWAP of outright trades in the Anchor Contract during the Anchor Pricing Window
2. If the total volume of trades during the Anchor Pricing Window is below the Outright MVR, the Closing Price will be the TWAP of the Indicator Reference Price for the Anchor during the Anchor Contract Pricing Window

**Spread VWAP Contracts**

In order as listed, each spread VWAP Contract is priced using the following waterfall:

1. The Closing Price will be the VWAP of the VWAP Instruments for the respective spread VWAP Contract during the spread Pricing Window, where the price used in the VWAP will be the traded spread price, applied to the already established price for the other contract.
2. If the total volume of all trades considered in this calculation is below the respective spread MVR, the Closing Price will be the TWAP of Indicator Reference Price of the TWAP Instrument during the spread Pricing Window, applied to the already established price for the other contract.

For clarity, where there are multiple spreads, the MVR will be compared to the sum of the volumes across all spreads.

**Indicator Reference Price ("IRP")**

If trades have occurred during current day:
If [Current Bid[6] > Last Trade] Then [IRP = Current Bid]
If [Current Offer < Last Trade] Then [IRP = Current Offer]
Otherwise [IRP = Last Trade]
If no trades during current day:
If [Current Bid > Previous Close] Then [IRP = Current Bid]
If [Current Offer < Previous Close] Then [IRP = Current Offer]
Otherwise [IRP = Previous Close]

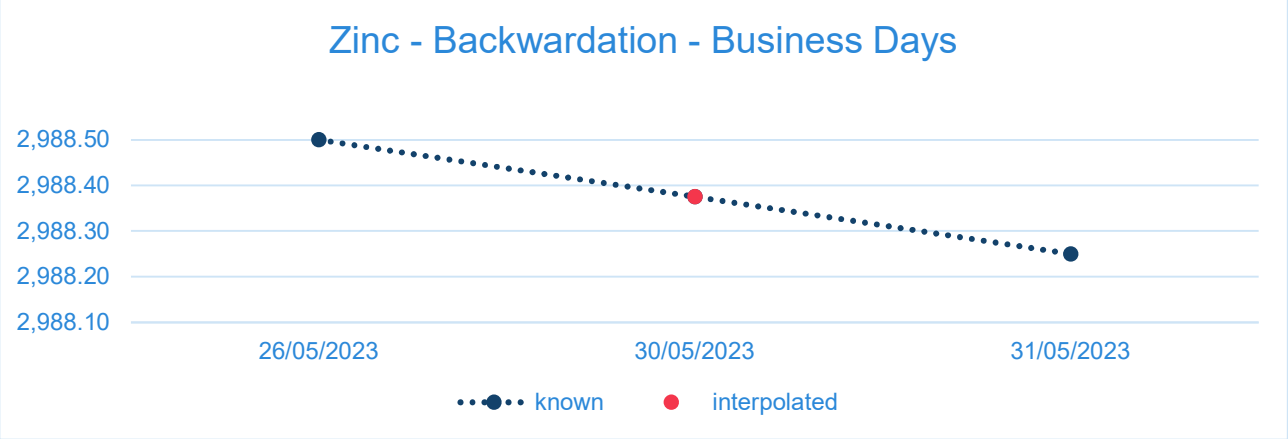
In the event that a Previous Close value is not available, which can occur if the 3M date was not tradable on the previous day, a linear interpolation is performed between the nearest available priced dates either side of the required date.

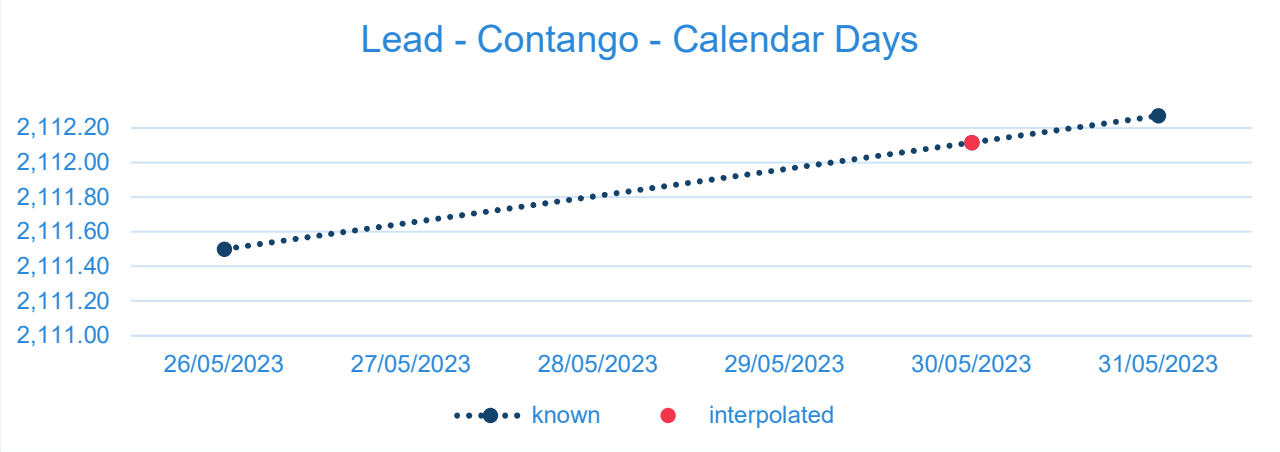
[6] Bids and offers during the relevant TWAP period.

Calendar days are used as the basis of interpolation if the two points are in Contango, otherwise Business days are used.

**Interpolation Examples**
Business Date: 28-Feb-2023
3M Prompt: 30-May-2023

| | | Previous Close | |
|---|---|---|---|
| Date | Date Type | Zinc | Lead |
| | | Backwardation | Contango |
| **26/05/2023** | | **2,988.50** | **2,111.50** |
| 27/05/2023 | Weekend | NA | 2,111.65 |
| 28/05/2023 | Weekend | NA | 2,111.81 |
| 29/05/2023 | Bank Holiday | NA | 2,111.96 |
| **30/05/2023** | | **2,988.38** | **2,112.12** |
| **31/05/2023** | | **2,988.25** | **2,112.27** |




### 1.2 Rest-of-curve (RC) methodology

When pricing the rest of the forward curve, including both the daily prompt dates and the longer dated monthly contracts, the LME's existing last price with expert judgement methodology will be used. It should be noted that the RC methodology will always follow after the completion of the FC methodology. As such prices

established during the FC methodology will not be changed on the basis of data considered within the RC methodology.

## 2 Pricing examples for the front-of-curve methodology

The below example prices Copper on 15 April 2021 (such that M1 is the April 3rd Wednesday contract, and 3m is 15 July 2021). The prices used are for example only, and are not the prices which traded on 15 April 2021.

**3-month** Closing Price calculated by a VWAP of all 3-month trades between 16:45-16:50 eg $9,201
Jun (M3), May (M2), Jul (M4) and Apr (M1) are then all calculated in this order using trades between 16:40 and 16:45: Please note as per convention, backwardations are noted as a positive number and contango as negative
**Jun21 (M3)** price is calculated as VWAP of all Jun21-3M (M3-3M) spread trades, applied to 3M:

| Instrument | Volume (lots) | Spread price | Known basis price | Price used in VWAP i.e. the 3m price +/- the spread price | VWAP price * volume |
|---|---|---|---|---|---|
| Jun21-3m | 100 | $5 | $9,201 | $9,206 | $920,600 |
| Jun21-3m | 50 | $4 | | $9,205 | $460,250 |
| Jun21-3m | 200 | $4.5 | | $9,205.5 | $1,841,100 |
| Jun21-3m | 25 | $5 | | $9,206 | $230,150 |
| | | | | | |
| TOTAL | 375 | | | | $3,452,100 |

Established Jun21 price: $9,205.60

**May21 (M2)** price is then calculated as VWAP of all May21-Jun21 (M2-M3) trades, and May21-3m (M2-3m) trades:

| Instrument | Volume (lots) | Spread price | Known basis price | Price used in VWAP | VWAP price * volume |
|---|---|---|---|---|---|
| May21-Jun21 | 50 | $2.25 | $ 9205.60 | $9207.85 | $460,392.5 |
| May21-Jun21 | 250 | $2.5 | $ 9205.60 | $9208.1 | $2,302,025 |
| May21-3m | 5 | $7.5 | $9,201 | $9,208.5 | $46,042.5 |
| May21-3m | 15 | $7 | $9,201 | $9,208 | $138,120 |
| | | | | | |
| Total | 320 | | | | $2,946,580 |

Established May21 price: $9,208.06

**Jul21 (M4)** price is then calculated as VWAP of all May21-Jul21 (M2-M4), Jun21-Jul21 (M3-M4) and 3m-Jul21 (3m-M4) trades:

| Instrument | Volume | Spread price | Known basis price | Price used in VWAP | VWAP price * volume |
|---|---|---|---|---|---|
| May21-Jul21 | 5 | $6 | $9,208.06 | $9,202.06 | $46,010.30 |
| May21-Jul21 | 1 | $4 | $9,208.06 | $9,204.06 | $9,204.06 |
| Jun21-Jul21 | 500 | $3 | $9,205.6 | $9,202.6 | $4,601,300 |
| 3m-Jul21 | 100 | $0 | $9,201 | $9,201 | $920,100 |
| 3m-Jul21 | 70 | -$0.5 | $9,201 | $9,201.5 | $644,105 |
| | | | | | |
| Total | 676 | | | | $6,220719.36 |

Established Jul21 price: $9,202.25 (rounded up from $9,202.2474)

**Apr21 (M1)** price is then calculated as VWAP of all Apr21-May21 (M1-M2), Apr21-Jun21 (M1-M3), Apr21-3m (M1-3m) and Apr-Jul21 (M1-M4) trades. If we assume there were no trades in any of those carries (during the spread Pricing Window), then Apr21 (M1) is priced as the TWAP of the Indicator Reference Price of Apr21-May21 (M1-M2), applied to the already established May21 (M2) price.

So given the following activity on Apr21-May21:

Previous day's Closing Price $3
Last trade prior to the Spread Pricing Window was $3.75
16:46 - 10 lot Bid at $4 entered (no orders in the book prior to this)
16:47 - 100 lot Offer at $4.5 entered
16:48 - 10 lot Bid at $4 removed
16:49 – 50 lot Offer at $3.5 entered

Then the IRP for the following periods is:

| Time Period | Duration of period | IRP of spread | Duration * IRP used in TWAP |
|---|---|---|---|
| 16:45 – 16:46 | 1 minute | $3.75 (no current orders, so use Last Trade) | $3.75 |
| 16:46 – 16:48 | 2 minutes | $4 (bid is higher than Last Trade. The higher $4.5 offer at 16:47 does not change the IRP) | $8 |
| 16:48 – 16:49 | 1 minutes | $3.75 (no better bid or offer than Last Trade) | $3.75 |
| 16:49 – 16:50 | 1 minutes | $3.5 (current offer is below Last Trade) | $3.5 |
| | | | |
| Total | 5 minutes | | $19 |

The TWAP of Apr21-May21 (M1-M2) is $3.8 ($19 / 5 minutes)

Established Apr21 price: $9,212.4 (rounded from $9208.6 + $3.8)

Whole minutes are used in this example for simplicity. The calculation will actually be done at a millisecond level as per market data timestamping.

**Cash** price is then calculated as the VWAP of Cash-Apr21 (Cash-M1). If we assume that there were no trades (during the spread Pricing Window), then Cash is priced on the basis of the TWAP of the IRP of Cash-Apr21.

If there have been no trades in Cash-Apr21 during the current trading day, then the IRP uses the previous day's Closing Price as reference (which will use today's Cash prompt date 19 Apr 2021, rather than the previous day's Cash prompt date).

If we assume the previous day's Closing Price for (today's) Cash-Apr21 was $0.5 and the bid/offer in Cash-Apr21 during the Spread Pricing Window was constant at $0 / $1, then the TWAP will only use the $0.5 from the previous day (as there is no better bid or offer).

Established Cash price: $9212.90 (9212.40 + 0.5)