CONTENTS

[**1.** **Background** 2](#_Toc32494793)

[**2.** **What is SOFR?** 2](#_Toc32494794)

[**3.** **IBORs and ARRs have different characteristics** 2](#_Toc32494795)

[**1.** **Averaged Overnight Rates** 2](#_Toc32494796)

[**2.** **Compounded setting in arrears rate** 5](#_Toc32494797)

[**3.** **Historical mean/median approach** 7](#_Toc32494798)

[**4.** **How to Build Term Structure** 12](#_Toc32494799)

[1. SOFR Term Structure using SOFR OIS 12](#_Toc32494800)

[2. LIBOR Term Structure in the case of permanent cessation 12](#_Toc32494801)

[**5.** **Question Lists** 12](#_Toc32494802)

[**6.** **Appendix** 12](#_Toc32494803)

[**1.** **SOFR DATA** 12](#_Toc32494804)

[**2.** **Spread data for static period** 14](#_Toc32494805)

[**7.** **Reference** 23](#_Toc32494806)

# **Background**

* 왜 LIBOR가 사라지는가?
* IBOR Benchmarks covered

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| LIBOR Currency | IBOR | IBOR Administrator | Alternative RFR | Alternative RFR Administrator | Public-/Private Sector Working Group | IBOR Tenors | IBOR Bloomberg Tickers | RFR Bloomberg Tickers | Adjusted RFRs | Credit Spreads |
| USD | LIBOR | IBA |  |  |  |  |  |  |  |  |
| EUR | LIBOR | IBA |  |  |  |  |  |  |  |  |
| Euro Interbank Offered Rate  (EURIBOR) | European Money Markets Institute  (EMMI) |  |  |  |  |  |  |  |  |
| GBP | LIBOR | IBA |  |  |  |  |  |  |  |  |
| JPY | LIBOR | IBA |  |  |  |  |  |  |  |  |
| Tokyo Interbank Offered Rate  (TIBOR) | Japanease Bankers Association TIBOR Administrator  (JBATA) |  |  |  |  |  |  |  |  |
| Euroyen  TIBOR | JBATA |  |  |  |  |  |  |  |  |
| CHF | London Interbank Offered Rate  (LIBOR) | ICE Benchmark Administrator  (IBA) |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

# **What is SOFR?**

* SOFR 정의, SOFR market에 대한 보충 설명, IBOR 대비 SOFR가 가지는 장점

## The Secured Overnight Financing Rate(SOFR)

* SOFR has a number of characteristics that LIBOR and other similar rates like LIBOR that are based on wholesale term unsecured funding markets do not:
* In June 2017, the ARRC announced a broad Treasury repo financing rate, SOFR, as its recommended alternative to USD LIBOR.

# **IBORs and ARRs have different characteristics**

* ARR(Alternative Reference Rate)는 각 국의 IBOR(Inter-Bank Offered Rate)에 대한 대체금리를 의미. 대표적으로 USD LIBOR에 대해서는 SOFR가 대체금리로 지정
* 각 Currency 별 ARR은 아래와 같다

|  |  |  |
| --- | --- | --- |
| **Currency** | **IBOR** | **Fallback Rate Index** |
| AUD | AUD BBSW | RBACOR |
| CHF | CHF LIBOR | SRFXON3 |
| GBP | GBP LIBOR | SONIO |
| JPY | JPY LIBOR | MUTKCALM |
| JPY | TIBOR | MUTKCALM |
| JPY | Euroyen TIBOR | MUTKCALM |
| CAD | CDOR | CORRA |
| HKD | HIBOR | HONIA |

**<IBOR to Fallback Rate Mapping>**

## **Averaged Overnight Rates**

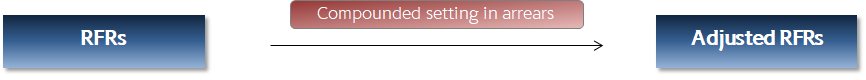
* Since RFRs are referenced by daily overnight rate while IBORs are term rates, a transformation of the RFR from spot rate to term rate is required to make comparison possible with the corresponding IBOR.[[1]](#footnote-1)

|  |  |
| --- | --- |
| **Adjusted SOFR** | **USD LIBOR** |
| 1M Average SOFR | 1M USD LIBOR |
| 2M Average SOFR | 2M USD LIBOR |
| 3M Average SOFR | 3M USD LIBOR |
| 6M Average SOFR | 6M USD LIBOR |
| 1Y Average SOFR | 1Y USD LIBOR |

* SOFR와 LIBOR의 가장 큰 차이는 SOFR는 overnight rate이고 IBOR는 term rate이라는 사실. 따라서 SOFR와 IBOR를 동등하게 만들어주려면 SOFR를 term rate으로 만들어줘야 함.
* Why financial products use an average of the overnight rate?[[2]](#footnote-2)
  + Accurately reflect movements in interest rates over a given period of time
  + Smooths out idiosyncratic, day to day fluctuations in market rates
* Overnight rate을 term rate으로 만드는 방법으로 주어진 기간의 overnight rate을 평균하는 방법을 제안. 이 방법은 주어진 기간 동안의 overnight rate 움직임을 잘 반영하며 또한 변동폭을 감소시키는 효과가 있음
* Recent Movement in SOFR versus Averaged SOFR[[3]](#footnote-3)
* SOFR와 비교했을 때 평균이 적용되는 기간이 길어질수록 rate의 움직임이 평탄해진다.
* 3-Month Average of SOFR versus 3-month LIBOR[[4]](#footnote-4)
* 심지어 3-month LIBOR보다 3-month average SOFR가 변동폭이 더 적다 여기서 3-month LIBOR와 3-month average SOFR의 차이는 LIBOR와 RFR의 credit 차이를 보여준다
* 결론적으로 Average SOFR가 이자율이 실제 움직임을 잘 반영하고, 변동성이 작다는 점에서 LIBOR를 대체하는 금리로서의 타당성이 있음.

## **Compounded setting in arrears rate**

* Compounded setting in arrears는 RFRs을 Adjusted RFRs로 만드는 과정이다.



* How these averages are calculated[[5]](#footnote-5)
  + Simple
  + Compound
  + Where   
     = the number of business day in the interest period

= the number of business day in the interest period

= the interest rate applicable on business day

= the number of calendar days for which rate applies (on most days, will be 1, but on a Friday it will generally be 3, and it will also be larger than 1 on the business day before a holiday). This can also be stated as the number of calendar days from and including business day to but excluding the following business day.

= the market convention for quoting the number of days in the year (in the United States, the convention for money markets is = 360, while in the UK it is =365)

And represents a series of ordinal numbers representing each business day in the period

* 평균을 계산하는 방법으로 simple과 compound 두 가지 방법이 있다. 경제적인 관점에서 compound 방법이 simple 방법보다 좀 더 정확하기 때문에 average SOFR를 계산할 때 compound 방법을 적용.
* Notice of payment
* In advance
* In arrear
* Fixing의 관점에서 In advance와 In arrear의 방법이 있음. LIBOR의 경우 대체로 In advance 방법을 사용하는 반면에 average SOFR는 interest rate의 실제 움직임을 잘 반영한다는 측면에서 In arrear 방법을 적용.
* The main disadvantage is that the information needed to calculate this rate is only available at the end of the relevant period[[6]](#footnote-6)



**[ Visualization of compounded setting in arrears rate calculation method ][[7]](#footnote-7)**

* Compound setting in arrear의 제일 큰 단점은 주어지 기간에 얼마를 Receive, Pay할지가 Payment date – 1bd 시점에 결정된다는 것이다. 여기서 1bd는 market convention에 따라 다를 수 있음
* 2019년 3월 26일 기준의 3M Average SOFR를 구하기 위해서는 2019년 3월 28일부터 2019년 6월 27일까지의 Daily SOFR가 필요하다. 2019년 6월 27일의 Daily SOFR가 고시가 되면 Compound setting in arrear의 산식을 통해서 2019년 3월 26일 기준의 3M Average SOFR를 계산할 수 있다

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Date(t)** | **Annualized**  **SOFR** | **Day Count**  **Fraction** | **Daily SOFR** | **1+Daily SOFR** |
| 2019-03-26 | 0.024 | 1/365 | 6.66667E-05 | 1.0000667 |
| 2019-03-27 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-03-28 | 0.0243 | 0.0028 | 0.0000675 | 1.0000675 |
| ︙ | ︙ | ︙ | ︙ | ︙ |
| 2019-06-27 | 0.0242 | 0.0028 | 6.72222E-05 | 1.00006722 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Start Date**  **(Date(t)+Lag)** | **T+3M** | **End Date**  **(T+3M-1bd)** | **Day Count**  **Fraction(3M/365)** | **ARRf** | **Annualized**  **ARRf** |
| 2019-03-28 | 2019-06-28 | 2019-06-27 | 92/365 | 0.006242 | 0.024424 |

## **Historical mean/median approach**

* IBORs contain a risk premium while the newly proposed RFRs are (nearly) risk-free. As these risk premium factors are not present in the current RFR, we will add a spread to the RFR[[8]](#footnote-8)
* IBOR와 SOFR의 가장 큰 차이점 중 하나는 IBOR는 credit이 반영된 rate인 반면에, SOFR를 비롯한 ARR(Alternative Reference Rate)은 RFR(Risk Free Rate)이라는 것이다. 이러한 credit의 차이는 ARR에 spread를 가산하는 방법으로 반영함
* The Historical mean/median approach to the spread adjustment is based on the mean or median spot spread between the IBOR and the adjusted RFR calculated over a static look-back period[[9]](#footnote-9)
  + Static look-back period will be 5 years or 10 years?
  + Mean approach or median approach?
* Spread는 static look-back period 동안의 LIBOR와 average SOFR의 spread의 mean 또는 median으로 계산됨. Static look-back period가 5년 또는 10년이 좋을지에 대한 논의가 있었고, spread를 mean 또는 median으로 적용할지에 대한 논의가 있었음. 현재는 5 years- median의 조합으로 결정되는 분위기임.
* ISDA의 기본적인 접근은 다음과 같다. IBOR와 RFR의 credit 차이를 spread로 확인할 수 있으며 과거의 정해진 기간 동안의 spread 시계열 데이터를 통해서 spread의 분포를 확인할 수 있다. IBOR가 중단된 이후에는 RFR에 spread를 가산해서 IBOR의 효과를 내야 하는데 이 때 가산되는 spread를 앞서 말한 분포의 mean 또는 median으로 결정하겠다는 것이다. 2014년 3월 27일부터 2019년 3월 26일까지의 3 month USD LIBOR와 adjusted SOFR의 spread의 히스토그램으로 5년의 static look-back period 동안의 spread 분포를 확인할 수 있다.

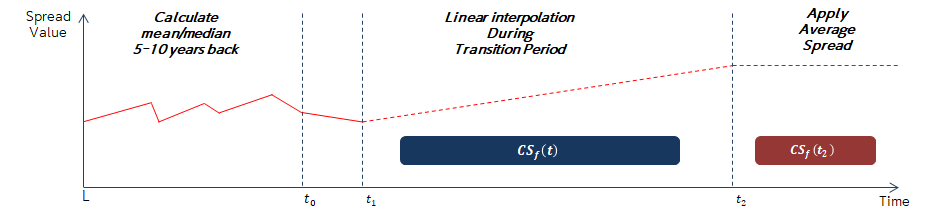
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Bins** | **Freq** | **Bins** | **Freq** | **Bins** | **Freq** | **Bins** | **Freq** |
| 5.6 | 23 | 20.23976 | 72 | 34.87952 | 32 | 49.51928 | 12 |
| 8.03996 | 8 | 22.67972 | 115 | 37.31948 | 24 | 51.95924 | 28 |
| 10.47992 | 20 | 25.11968 | 135 | 39.75944 | 42 | 54.39921 | 2 |
| 12.91988 | 163 | 27.55964 | 54 | 42.1994 | 19 | 56.83917 | 0 |
| 15.35984 | 267 | 29.9996 | 36 | 44.63936 | 50 |  |  |
| 17.7998 | 74 | 32.43956 | 43 | 47.07932 | 29 |  |  |

**< Frequency of historical basis-point spreads between 3 months USD LIBOR  
 and adjusted RFR in the 5 years look-back period >**

* It will be calculated and published for each relevant IBOR tenor based on historical differences between the IBOR for that tenor and the corresponding RFR compounded over a time period with the same length as the tenor.[[10]](#footnote-10)
* Spread는 Tenor에 따라 다름. 예를 들어 1M USD LIBOR에 대응되는 1M Ave SOFR에 적용되는 Spread(1M)와 3M USD LIBOR에 대응되는 3M Ave SOFR에 적용되는 Spread(3M)는 다르게 계산됨

|  |  |  |
| --- | --- | --- |
| **Adjusted SOFR** | **SPREAD** | **USD LIBOR** |
| 1M Average SOFR | Spread(1M) | 1M USD LIBOR |
| 2M Average SOFR | Spread (2M) | 2M USD LIBOR |
| 3M Average SOFR | Spread (3M) | 3M USD LIBOR |
| 6M Average SOFR | Spread (6M) | 6M USD LIBOR |
| 1Y Average SOFR | Spread (1Y) | 1Y USD LIBOR |

* 정리하자면, USD LIBOR에 대한 Fallback Rate은 아래와 같이 계산된다.
* Once calculated, the long-run spread adjustment will be set(i.e., it will not be dynamic or reflect any changes in the interbank market prices once the fallback trigger event occurs)[[11]](#footnote-11)
* Fallback Trigger Event가 발생하면, spread는 IBOR의 시장가격의 변화를 전혀 반영하지 않는다. 다시 말해, Fallback Trigger Event 이후에 적용되는 spread는 고정된다는 것이다.
* In the case of a sudden permanent discontinuation, the calculation and application of the spread adjustment would be contemporaneous but in the case of a permanent discontinuation that is announced in advance, there will be a period of time between the calculation of the spread adjustment and the application of the fallback. [[12]](#footnote-12)
* IBOR의 중단과 RFR로의 대체는 사전에 고시가 될 것이고 영구적이기 때문에, permanent discontinuation case만 고려하면 장기적으로 적용되는 spread의 계산시점과 적용시점은 차이가 있다.
* Calculating the long-run spread adjustment as of the business day before the fallback trigger event occurs is necessary to avoid distortions due to market disruption during the period between when the fallback is triggered and when it becomes applicable.[[13]](#footnote-13)
* Spread의 계산시점과 적용시점에 차이를 두는 것은 fallback trigger event로 인한 시장혼란을 피하기 위함이다.
* Pursuant to the 2018 consultations, the spread adjustment calculated in accordance with the final historical mean/median approach could be used from the end of a one-year transitional period after the fallback applies.[[14]](#footnote-14)
* Fallback이 적용되는 시점부터 1년간의 transitional period가 존재한다.
* During the transitional period, the spread to be used would be calculated using linear interpolation between the IBOR/adjusted RFR spread around the time the fallback applies and the historical mean/mean spread that would apply after the end of the transitional period[[15]](#footnote-15)
* Transition period 동안 적용되는 spread는 liner interpolation을 통해 계산된다. Historical mean/median spread(long-run spread adjustment를 의미) 는 period가 끝나는 시점에 적용된다.
* The one-year transitional period would help mitigate against (although not eliminate) a “cliff effect” at the time the fallback applies if the spot IBOR/adjusted RFR spread at that time differs from the historical mean/median.[[16]](#footnote-16)
* 앞서 얘기했듯이, transition period가 존재하는 이유는 fallback rate 적용시점에서의 spread(spot spread)와 static look-back period동안 계산된 spread의 mean/median이 다르기 때문에 그 차이를 완화하기 위함이다.



**< Visualization of Setting the Spread >[[17]](#footnote-17)**

* Mathematical formula to calculate the credit spread for both the transition period and the period after the transition period[[18]](#footnote-18)
* The fallback rate between the transition period, , is defined as:[[19]](#footnote-19)
* The fallback rate after the transition period will be:[[20]](#footnote-20)

# **How to Build Term Structure**

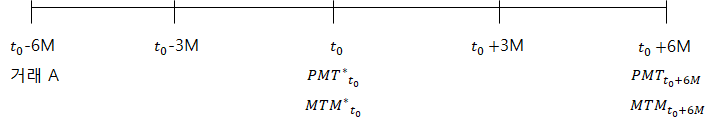
## SOFR Term Structure using SOFR OIS

## LIBOR Term Structure in the case of permanent cessation

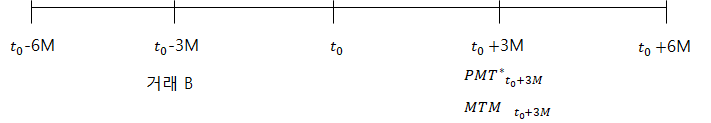
# **Question Lists**

## **For derivatives, target for cessation of new use of USD Libor by 06/30/2021**

* USD LIBOR 6M를 reference rate로 한 만기 1년까리 거래 2개를 예로 들어본다. 거래A는 2021/06/30에 체결된 거래이고, 거래B는 2021/09/30에 체결된 거래로 가정한다. 를 2021/12/31로 가정했을 때, 은 2021/06/30이고 은 2021/09/30이다.



**거래 A의 timeline**



**거래 B의 timeline**

* 시점에서 거래 A의 시점의 payment를 알 수 있다. 또한 시점부터 LIBOR가 고시가 안되기 때문에 시점부터는 Fallback Rate으로 payment가 결정된다.
* 마찬가지로 시점에서 거래 B의 시점의 payment를 알 수 있다. 또한 시점부터는 Fallback Rate으로 payment가 결정된다.
* 시점부터 거래 당사자는 리보중단으로 인한 자신의 계약의 유/불리를 계산한다. 시점에서는 시점에 fixing된 LIBOR와 그에 대응되는 Fallback Rate을 비교할 수 있기 때문에 거래 A의 유/불리를 비교할 수 있다. 반면에 시점에서는 시점에 fixing된 LIBOR와 그에 대응되는 Fallback Rate을 비교할 수 없기 때문에 거래 B의 유/불리를 비교할 수 없다.
* 거래 B의 경우 시점에 도달했을 때 시점에 fixing된 LIBOR와 그에 대응되는 Fallback Rate을 비교할 수 있다.
* 또한 거래 A의 당사자들은 시점에서 (1) reference rate이 LIBOR인 경우의 MTM과 (2) 리보가 중단되어 Fallback으로 대체되었을 때의 MTM을 각각 구할 수 있다. 반면에 거래 B의 당사자들은 시점에서 (1) reference rate이 LIBOR인 경우의 MTM을 구할 수 없고, 오직 (2) 리보가 중단되어 Fallback으로 대체되었을 때의 MTM만 구할 수 있다.
* 파생상품의 경우 대부분 SWAP의 형태이고, USD LIBOR 6M와 USD LIBOR 3M을 주로 reference rate으로 한다는 것을 고려하면 시점에서 6M 전부터는 USD LIBOR를 기초자산으로 한 파생상품의 발행 및 신규계약을 지양하는 것이 LIBOR가 SOFR로 대체되면서 발생하는위험을 줄일 수 있다.

# **Appendix**

## **SOFR DATA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date(t) | Annualized  SOFR | Day Count  Fraction | Daily SOFR | 1+Daily SOFR |
| 2019-03-26 | 0.024 | 1/365 | 6.66667E-05 | 1.0000667 |
| 2019-03-27 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-03-28 | 0.0243 | 0.0028 | 0.0000675 | 1.0000675 |
| 2019-03-29 | 0.0265 | 0.0083 | 0.000220833 | 1.00022083 |
| 2019-04-01 | 0.0246 | 0.0028 | 6.83333E-05 | 1.00006833 |
| 2019-04-02 | 0.0246 | 0.0028 | 6.83333E-05 | 1.00006833 |
| 2019-04-03 | 0.0247 | 0.0028 | 6.86111E-05 | 1.00006861 |
| 2019-04-04 | 0.0246 | 0.0028 | 6.83333E-05 | 1.00006833 |
| 2019-04-05 | 0.0246 | 0.0083 | 0.000205 | 1.000205 |
| 2019-04-08 | 0.0246 | 0.0028 | 6.83333E-05 | 1.00006833 |
| 2019-04-09 | 0.0245 | 0.0028 | 6.80556E-05 | 1.00006806 |
| 2019-04-10 | 0.0245 | 0.0028 | 6.80556E-05 | 1.00006806 |
| 2019-04-11 | 0.0244 | 0.0028 | 6.77778E-05 | 1.00006778 |
| 2019-04-12 | 0.0244 | 0.0083 | 0.000203333 | 1.00020333 |
| 2019-04-15 | 0.0247 | 0.0028 | 6.86111E-05 | 1.00006861 |
| 2019-04-16 | 0.0247 | 0.0028 | 6.86111E-05 | 1.00006861 |
| 2019-04-17 | 0.025 | 0.0028 | 6.94444E-05 | 1.00006944 |
| 2019-04-18 | 0.025 | 0.0111 | 0.000277778 | 1.00027778 |
| 2019-04-22 | 0.0246 | 0.0028 | 6.83333E-05 | 1.00006833 |
| 2019-04-23 | 0.0246 | 0.0028 | 6.83333E-05 | 1.00006833 |
| 2019-04-24 | 0.0244 | 0.0028 | 6.77778E-05 | 1.00006778 |
| 2019-04-25 | 0.0245 | 0.0028 | 6.80556E-05 | 1.00006806 |
| 2019-04-26 | 0.0246 | 0.0083 | 0.000205 | 1.000205 |
| 2019-04-29 | 0.0248 | 0.0028 | 6.88889E-05 | 1.00006889 |
| 2019-04-30 | 0.0276 | 0.0028 | 7.66667E-05 | 1.00007667 |
| 2019-05-01 | 0.0254 | 0.0028 | 7.05556E-05 | 1.00007056 |
| 2019-05-02 | 0.025 | 0.0028 | 6.94444E-05 | 1.00006944 |
| 2019-05-03 | 0.0243 | 0.0083 | 0.0002025 | 1.0002025 |
| 2019-05-06 | 0.0242 | 0.0028 | 6.72222E-05 | 1.00006722 |
| 2019-05-07 | 0.0244 | 0.0028 | 6.77778E-05 | 1.00006778 |
| 2019-05-08 | 0.0243 | 0.0028 | 0.0000675 | 1.0000675 |
| 2019-05-09 | 0.0241 | 0.0028 | 6.69444E-05 | 1.00006694 |
| 2019-05-10 | 0.024 | 0.0083 | 0.0002 | 1.0002 |
| 2019-05-13 | 0.0238 | 0.0028 | 6.61111E-05 | 1.00006611 |
| 2019-05-14 | 0.0239 | 0.0028 | 6.63889E-05 | 1.00006639 |
| 2019-05-15 | 0.0248 | 0.0028 | 6.88889E-05 | 1.00006889 |
| 2019-05-16 | 0.0243 | 0.0028 | 0.0000675 | 1.0000675 |
| 2019-05-17 | 0.0242 | 0.0083 | 0.000201667 | 1.00020167 |
| 2019-05-20 | 0.0239 | 0.0028 | 6.63889E-05 | 1.00006639 |
| 2019-05-21 | 0.0238 | 0.0028 | 6.61111E-05 | 1.00006611 |
| 2019-05-22 | 0.0237 | 0.0028 | 6.58333E-05 | 1.00006583 |
| 2019-05-23 | 0.0237 | 0.0028 | 6.58333E-05 | 1.00006583 |
| 2019-05-24 | 0.0237 | 0.0111 | 0.000263333 | 1.00026333 |
| 2019-05-28 | 0.0241 | 0.0028 | 6.69444E-05 | 1.00006694 |
| 2019-05-29 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-05-30 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-05-31 | 0.0249 | 0.0083 | 0.0002075 | 1.0002075 |
| 2019-06-03 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-06-04 | 0.0239 | 0.0028 | 6.63889E-05 | 1.00006639 |
| 2019-06-05 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-06-06 | 0.024 | 0.0028 | 6.66667E-05 | 1.00006667 |
| 2019-06-07 | 0.0239 | 0.0083 | 0.000199167 | 1.00019917 |
| 2019-06-10 | 0.0239 | 0.0028 | 6.63889E-05 | 1.00006639 |
| 2019-06-11 | 0.0238 | 0.0028 | 6.61111E-05 | 1.00006611 |
| 2019-06-12 | 0.0237 | 0.0028 | 6.58333E-05 | 1.00006583 |
| 2019-06-13 | 0.0235 | 0.0028 | 6.52778E-05 | 1.00006528 |
| 2019-06-14 | 0.0235 | 0.0083 | 0.000195833 | 1.00019583 |
| 2019-06-17 | 0.0241 | 0.0028 | 6.69444E-05 | 1.00006694 |
| 2019-06-18 | 0.0239 | 0.0028 | 6.63889E-05 | 1.00006639 |
| 2019-06-19 | 0.0236 | 0.0028 | 6.55556E-05 | 1.00006556 |
| 2019-06-20 | 0.0236 | 0.0028 | 6.55556E-05 | 1.00006556 |
| 2019-06-21 | 0.0237 | 0.0083 | 0.0001975 | 1.0001975 |
| 2019-06-24 | 0.0239 | 0.0028 | 6.63889E-05 | 1.00006639 |
| 2019-06-25 | 0.0241 | 0.0028 | 6.69444E-05 | 1.00006694 |
| 2019-06-26 | 0.0243 | 0.0028 | 0.0000675 | 1.0000675 |
| 2019-06-27 | 0.0242 | 0.0028 | 6.72222E-05 | 1.00006722 |

## **Spread data for static period**

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| Num | Lookback  period | Spread | Num | Lookback  period | Spread | Num | Lookback  period | Spread |
| 1 | 2014-03-27 | 17.78819 | 140 | 2014-10-15 | 13.42992 | 279 | 2015-05-08 | 15.79837 |
| 2 | 2014-03-28 | 17.73022 | 141 | 2014-10-16 | 13.78045 | 280 | 2015-05-11 | 15.35377 |
| 3 | 2014-03-31 | 17.42225 | 142 | 2014-10-17 | 13.82957 | 281 | 2015-05-12 | 15.08504 |
| 4 | 2014-04-01 | 17.16125 | 143 | 2014-10-20 | 13.91545 | 282 | 2015-05-13 | 14.7071 |
| 5 | 2014-04-02 | 17.29682 | 144 | 2014-10-21 | 13.77632 | 283 | 2015-05-14 | 14.78274 |
| 6 | 2014-04-03 | 17.29833 | 145 | 2014-10-22 | 14.04487 | 284 | 2015-05-15 | 14.70226 |
| 7 | 2014-04-04 | 17.21234 | 146 | 2014-10-23 | 14.10893 | 285 | 2015-05-18 | 14.52178 |
| 8 | 2014-04-07 | 17.17635 | 147 | 2014-10-24 | 14.09155 | 286 | 2015-05-19 | 14.91305 |
| 9 | 2014-04-08 | 16.97135 | 148 | 2014-10-27 | 14.06329 | 287 | 2015-05-20 | 15.06052 |
| 10 | 2014-04-09 | 16.98536 | 149 | 2014-10-28 | 14.08504 | 288 | 2015-05-21 | 14.63249 |
| 11 | 2014-04-10 | 16.90239 | 150 | 2014-10-29 | 14.12064 | 289 | 2015-05-22 | 14.80637 |
| 12 | 2014-04-11 | 16.8314 | 151 | 2014-10-30 | 14.22312 | 290 | 2015-05-26 | 14.86526 |
| 13 | 2014-04-14 | 17.04041 | 152 | 2014-10-31 | 14.20899 | 291 | 2015-05-27 | 14.51777 |
| 14 | 2014-04-15 | 16.78842 | 153 | 2014-11-03 | 14.23399 | 292 | 2015-05-28 | 14.32692 |
| 15 | 2014-04-16 | 16.8505 | 154 | 2014-11-04 | 14.15137 | 293 | 2015-05-29 | 14.33993 |
| 16 | 2014-04-17 | 16.63951 | 155 | 2014-11-05 | 14.035 | 294 | 2015-06-01 | 14.14969 |
| 17 | 2014-04-21 | 16.61753 | 156 | 2014-11-06 | 13.89806 | 295 | 2015-06-02 | 13.75882 |
| 18 | 2014-04-22 | 16.88154 | 157 | 2014-11-07 | 13.9437 | 296 | 2015-06-03 | 13.86482 |
| 19 | 2014-04-23 | 16.87456 | 158 | 2014-11-10 | 13.95021 | 297 | 2015-06-04 | 13.70271 |
| 20 | 2014-04-24 | 16.68564 | 159 | 2014-11-12 | 13.91886 | 298 | 2015-06-05 | 13.92183 |
| 21 | 2014-04-25 | 16.52767 | 160 | 2014-11-13 | 13.79585 | 299 | 2015-06-08 | 14.01096 |
| 22 | 2014-04-28 | 16.33069 | 161 | 2014-11-14 | 13.8176 | 300 | 2015-06-09 | 14.28659 |
| 23 | 2014-04-29 | 16.33887 | 162 | 2014-11-17 | 13.80347 | 301 | 2015-06-10 | 14.49516 |
| 24 | 2014-04-30 | 16.0579 | 163 | 2014-11-18 | 13.81434 | 302 | 2015-06-11 | 14.22373 |
| 25 | 2014-05-01 | 15.9258 | 164 | 2014-11-19 | 13.86423 | 303 | 2015-06-12 | 14.22198 |
| 26 | 2014-05-02 | 15.90406 | 165 | 2014-11-20 | 14.04981 | 304 | 2015-06-15 | 13.93111 |
| 27 | 2014-05-05 | 15.88231 | 166 | 2014-11-21 | 14.0883 | 305 | 2015-06-16 | 14.20936 |
| 28 | 2014-05-06 | 16.06057 | 167 | 2014-11-24 | 14.28178 | 306 | 2015-06-17 | 14.23759 |
| 29 | 2014-05-07 | 15.99022 | 168 | 2014-11-25 | 14.4632 | 307 | 2015-06-18 | 13.58825 |
| 30 | 2014-05-08 | 15.85622 | 169 | 2014-11-26 | 14.52603 | 308 | 2015-06-19 | 13.58388 |
| 31 | 2014-05-09 | 15.90947 | 170 | 2014-11-28 | 14.37013 | 309 | 2015-06-22 | 13.63539 |
| 32 | 2014-05-12 | 15.9986 | 171 | 2014-12-01 | 14.51458 | 310 | 2015-06-23 | 13.44189 |
| 33 | 2014-05-13 | 15.85186 | 172 | 2014-12-02 | 14.57015 | 311 | 2015-06-24 | 13.50846 |
| 34 | 2014-05-14 | 15.95998 | 173 | 2014-12-03 | 14.6396 | 312 | 2015-06-25 | 13.56689 |
| 35 | 2014-05-15 | 15.9214 | 174 | 2014-12-04 | 14.80879 | 313 | 2015-06-26 | 13.54189 |
| 36 | 2014-05-16 | 16.17466 | 175 | 2014-12-05 | 14.87019 | 314 | 2015-06-29 | 13.67165 |
| 37 | 2014-05-19 | 15.99879 | 176 | 2014-12-08 | 15.10353 | 315 | 2015-06-30 | 13.62165 |
| 38 | 2014-05-20 | 16.10292 | 177 | 2014-12-09 | 15.25076 | 316 | 2015-07-01 | 13.70514 |
| 39 | 2014-05-21 | 16.02166 | 178 | 2014-12-10 | 15.41133 | 317 | 2015-07-02 | 13.70602 |
| 40 | 2014-05-22 | 15.96443 | 179 | 2014-12-11 | 15.55362 | 318 | 2015-07-06 | 13.78102 |
| 41 | 2014-05-23 | 16.18443 | 180 | 2014-12-12 | 15.81746 | 319 | 2015-07-07 | 13.68102 |
| 42 | 2014-05-27 | 16.2453 | 181 | 2014-12-15 | 15.79246 | 320 | 2015-07-08 | 13.78437 |
| 43 | 2014-05-28 | 16.08574 | 182 | 2014-12-16 | 15.74801 | 321 | 2015-07-09 | 14.02126 |
| 44 | 2014-05-29 | 16.10402 | 183 | 2014-12-17 | 16.02301 | 322 | 2015-07-10 | 14.02301 |
| 45 | 2014-05-30 | 16.13076 | 184 | 2014-12-18 | 16.31353 | 323 | 2015-07-13 | 14.32301 |
| 46 | 2014-06-02 | 16.1275 | 185 | 2014-12-19 | 16.83137 | 324 | 2015-07-14 | 14.30388 |
| 47 | 2014-06-03 | 16.16337 | 186 | 2014-12-22 | 17.13137 | 325 | 2015-07-15 | 14.2409 |
| 48 | 2014-06-04 | 16.39626 | 187 | 2014-12-23 | 16.89866 | 326 | 2015-07-16 | 14.04515 |
| 49 | 2014-06-05 | 16.53773 | 188 | 2014-12-24 | 17.09244 | 327 | 2015-07-17 | 14.50927 |
| 50 | 2014-06-06 | 16.45947 | 189 | 2014-12-29 | 16.89799 | 328 | 2015-07-20 | 14.83427 |
| 51 | 2014-06-09 | 16.57622 | 190 | 2014-12-30 | 16.68571 | 329 | 2015-07-21 | 14.74427 |
| 52 | 2014-06-10 | 16.57296 | 191 | 2014-12-31 | 16.58099 | 330 | 2015-07-22 | 14.67282 |
| 53 | 2014-06-11 | 16.5965 | 192 | 2015-01-02 | 16.57013 | 331 | 2015-07-23 | 14.9965 |
| 54 | 2014-06-12 | 16.73341 | 193 | 2015-01-05 | 16.31456 | 332 | 2015-07-24 | 14.94436 |
| 55 | 2014-06-13 | 16.93777 | 194 | 2015-01-06 | 16.00899 | 333 | 2015-07-27 | 15.09223 |
| 56 | 2014-06-16 | 16.82038 | 195 | 2015-01-07 | 16.05342 | 334 | 2015-07-28 | 15.46009 |
| 57 | 2014-06-17 | 16.893 | 196 | 2015-01-08 | 15.78033 | 335 | 2015-07-29 | 15.65622 |
| 58 | 2014-06-18 | 16.96122 | 197 | 2015-01-09 | 15.96447 | 336 | 2015-07-30 | 16.42074 |
| 59 | 2014-06-19 | 16.87258 | 198 | 2015-01-12 | 15.76779 | 337 | 2015-07-31 | 17.37947 |
| 60 | 2014-06-20 | 17.00519 | 199 | 2015-01-13 | 15.75111 | 338 | 2015-08-03 | 16.9982 |
| 61 | 2014-06-23 | 17.24868 | 200 | 2015-01-14 | 15.6922 | 339 | 2015-08-04 | 16.79257 |
| 62 | 2014-06-24 | 17.40304 | 201 | 2015-01-15 | 15.31435 | 340 | 2015-08-05 | 17.93886 |
| 63 | 2014-06-25 | 17.54414 | 202 | 2015-01-16 | 15.69212 | 341 | 2015-08-06 | 18.25749 |
| 64 | 2014-06-26 | 17.70307 | 203 | 2015-01-20 | 15.69101 | 342 | 2015-08-07 | 18.45904 |
| 65 | 2014-06-27 | 17.85091 | 204 | 2015-01-21 | 15.7199 | 343 | 2015-08-10 | 18.7767 |
| 66 | 2014-06-30 | 17.51527 | 205 | 2015-01-22 | 15.59778 | 344 | 2015-08-11 | 18.90043 |
| 67 | 2014-07-01 | 17.64701 | 206 | 2015-01-23 | 15.56433 | 345 | 2015-08-12 | 18.55571 |
| 68 | 2014-07-02 | 18.02485 | 207 | 2015-01-26 | 15.53098 | 346 | 2015-08-13 | 19.93947 |
| 69 | 2014-07-03 | 17.78572 | 208 | 2015-01-27 | 15.14764 | 347 | 2015-08-14 | 20.45407 |
| 70 | 2014-07-07 | 18.00746 | 209 | 2015-01-28 | 15.3143 | 348 | 2015-08-17 | 21.42455 |
| 71 | 2014-07-08 | 17.95746 | 210 | 2015-01-29 | 15.03009 | 349 | 2015-08-18 | 21.53328 |
| 72 | 2014-07-09 | 17.98857 | 211 | 2015-01-30 | 14.86423 | 350 | 2015-08-19 | 21.83331 |
| 73 | 2014-07-10 | 17.95746 | 212 | 2015-02-02 | 14.74801 | 351 | 2015-08-20 | 21.56057 |
| 74 | 2014-07-11 | 17.95746 | 213 | 2015-02-03 | 15.02553 | 352 | 2015-08-21 | 21.65842 |
| 75 | 2014-07-14 | 17.83572 | 214 | 2015-02-04 | 15.02553 | 353 | 2015-08-24 | 21.99714 |
| 76 | 2014-07-15 | 17.85311 | 215 | 2015-02-05 | 15.35596 | 354 | 2015-08-25 | 21.57889 |
| 77 | 2014-07-16 | 17.71066 | 216 | 2015-02-06 | 15.30316 | 355 | 2015-08-26 | 21.39076 |
| 78 | 2014-07-17 | 17.72917 | 217 | 2015-02-09 | 15.56407 | 356 | 2015-08-27 | 21.43851 |
| 79 | 2014-07-18 | 17.50743 | 218 | 2015-02-10 | 15.53907 | 357 | 2015-08-28 | 21.95347 |
| 80 | 2014-07-21 | 17.64656 | 219 | 2015-02-11 | 15.56154 | 358 | 2015-08-31 | 22.0524 |
| 81 | 2014-07-22 | 17.57481 | 220 | 2015-02-12 | 15.53093 | 359 | 2015-09-01 | 22.62934 |
| 82 | 2014-07-23 | 17.65426 | 221 | 2015-02-13 | 15.40535 | 360 | 2015-09-02 | 22.47934 |
| 83 | 2014-07-24 | 17.75959 | 222 | 2015-02-17 | 15.36535 | 361 | 2015-09-03 | 22.4914 |
| 84 | 2014-07-25 | 17.65959 | 223 | 2015-02-18 | 15.76659 | 362 | 2015-09-04 | 22.27545 |
| 85 | 2014-07-28 | 17.84872 | 224 | 2015-02-19 | 15.88782 | 363 | 2015-09-08 | 22.17652 |
| 86 | 2014-07-29 | 17.9161 | 225 | 2015-02-20 | 15.94001 | 364 | 2015-09-09 | 22.23255 |
| 87 | 2014-07-30 | 17.97018 | 226 | 2015-02-23 | 15.7698 | 365 | 2015-09-10 | 22.49958 |
| 88 | 2014-07-31 | 17.94217 | 227 | 2015-02-24 | 15.64801 | 366 | 2015-09-11 | 22.60859 |
| 89 | 2014-08-01 | 17.83129 | 228 | 2015-02-25 | 15.59429 | 367 | 2015-09-14 | 22.37263 |
| 90 | 2014-08-04 | 17.72042 | 229 | 2015-02-26 | 15.56077 | 368 | 2015-09-15 | 22.11573 |
| 91 | 2014-08-05 | 17.70955 | 230 | 2015-02-27 | 15.55316 | 369 | 2015-09-16 | 22.43089 |
| 92 | 2014-08-06 | 17.41954 | 231 | 2015-03-02 | 15.39792 | 370 | 2015-09-17 | 22.18945 |
| 93 | 2014-08-07 | 17.27728 | 232 | 2015-03-03 | 15.7853 | 371 | 2015-09-18 | 19.37961 |
| 94 | 2014-08-08 | 17.47694 | 233 | 2015-03-04 | 15.64577 | 372 | 2015-09-21 | 19.87273 |
| 95 | 2014-08-11 | 17.33607 | 234 | 2015-03-05 | 15.6303 | 373 | 2015-09-22 | 19.71388 |
| 96 | 2014-08-12 | 17.23345 | 235 | 2015-03-06 | 15.71943 | 374 | 2015-09-23 | 18.70716 |
| 97 | 2014-08-13 | 17.1893 | 236 | 2015-03-09 | 15.90856 | 375 | 2015-09-24 | 18.70356 |
| 98 | 2014-08-14 | 16.92474 | 237 | 2015-03-10 | 15.97507 | 376 | 2015-09-25 | 18.36576 |
| 99 | 2014-08-15 | 17.01387 | 238 | 2015-03-11 | 16.12679 | 377 | 2015-09-28 | 18.08597 |
| 100 | 2014-08-18 | 17.003 | 239 | 2015-03-12 | 16.14547 | 378 | 2015-09-29 | 16.56782 |
| 101 | 2014-08-19 | 17.20039 | 240 | 2015-03-13 | 16.16134 | 379 | 2015-09-30 | 16.47551 |
| 102 | 2014-08-20 | 17.18098 | 241 | 2015-03-16 | 16.15483 | 380 | 2015-10-01 | 15.9619 |
| 103 | 2014-08-21 | 17.15254 | 242 | 2015-03-17 | 16.10745 | 381 | 2015-10-02 | 16.00005 |
| 104 | 2014-08-22 | 17.46993 | 243 | 2015-03-18 | 16.28385 | 382 | 2015-10-05 | 15.2947 |
| 105 | 2014-08-25 | 17.42013 | 244 | 2015-03-19 | 15.68181 | 383 | 2015-10-06 | 14.49197 |
| 106 | 2014-08-26 | 17.36383 | 245 | 2015-03-20 | 15.93943 | 384 | 2015-10-07 | 13.87721 |
| 107 | 2014-08-27 | 16.84242 | 246 | 2015-03-23 | 15.93943 | 385 | 2015-10-08 | 13.31441 |
| 108 | 2014-08-28 | 16.6012 | 247 | 2015-03-24 | 16.21618 | 386 | 2015-10-09 | 13.14255 |
| 109 | 2014-08-29 | 16.51327 | 248 | 2015-03-25 | 16.14077 | 387 | 2015-10-13 | 12.8933 |
| 110 | 2014-09-02 | 16.38633 | 249 | 2015-03-26 | 16.60792 | 388 | 2015-10-14 | 11.72098 |
| 111 | 2014-09-03 | 16.42039 | 250 | 2015-03-27 | 16.85727 | 389 | 2015-10-15 | 11.43396 |
| 112 | 2014-09-04 | 16.05661 | 251 | 2015-03-30 | 16.76525 | 390 | 2015-10-16 | 11.38383 |
| 113 | 2014-09-05 | 15.89967 | 252 | 2015-03-31 | 16.46922 | 391 | 2015-10-19 | 11.02932 |
| 114 | 2014-09-08 | 15.96372 | 253 | 2015-04-01 | 16.55715 | 392 | 2015-10-20 | 11.05632 |
| 115 | 2014-09-09 | 16.00877 | 254 | 2015-04-02 | 16.87914 | 393 | 2015-10-21 | 9.644551 |
| 116 | 2014-09-10 | 15.93183 | 255 | 2015-04-06 | 16.90112 | 394 | 2015-10-22 | 9.407632 |
| 117 | 2014-09-11 | 15.65102 | 256 | 2015-04-07 | 16.9231 | 395 | 2015-10-23 | 9.392234 |
| 118 | 2014-09-12 | 15.63507 | 257 | 2015-04-08 | 16.6791 | 396 | 2015-10-26 | 9.069205 |
| 119 | 2014-09-15 | 15.54714 | 258 | 2015-04-09 | 17.18207 | 397 | 2015-10-27 | 8.763545 |
| 120 | 2014-09-16 | 15.46119 | 259 | 2015-04-10 | 17.30306 | 398 | 2015-10-28 | 7.735648 |
| 121 | 2014-09-17 | 15.34326 | 260 | 2015-04-13 | 17.13306 | 399 | 2015-10-29 | 7.795267 |
| 122 | 2014-09-18 | 14.97948 | 261 | 2015-04-14 | 17.16905 | 400 | 2015-10-30 | 7.956342 |
| 123 | 2014-09-19 | 14.91353 | 262 | 2015-04-15 | 17.06005 | 401 | 2015-11-02 | 7.619167 |
| 124 | 2014-09-22 | 15.10857 | 263 | 2015-04-16 | 17.23397 | 402 | 2015-11-03 | 7.231989 |
| 125 | 2014-09-23 | 14.92486 | 264 | 2015-04-17 | 17.30996 | 403 | 2015-11-04 | 6.959496 |
| 126 | 2014-09-24 | 14.96652 | 265 | 2015-04-20 | 17.32397 | 404 | 2015-11-05 | 7.022034 |
| 127 | 2014-09-25 | 14.63379 | 266 | 2015-04-21 | 17.44897 | 405 | 2015-11-06 | 6.456597 |
| 128 | 2014-09-26 | 14.52883 | 267 | 2015-04-22 | 17.441 | 406 | 2015-11-09 | 7.158696 |
| 129 | 2014-09-29 | 14.65955 | 268 | 2015-04-23 | 17.19314 | 407 | 2015-11-10 | 6.525491 |
| 130 | 2014-09-30 | 14.59597 | 269 | 2015-04-24 | 17.3162 | 408 | 2015-11-12 | 6.453417 |
| 131 | 2014-10-01 | 14.25897 | 270 | 2015-04-27 | 17.23926 | 409 | 2015-11-13 | 6.327084 |
| 132 | 2014-10-02 | 13.9994 | 271 | 2015-04-28 | 17.06632 | 410 | 2015-11-16 | 6.039869 |
| 133 | 2014-10-03 | 14.00678 | 272 | 2015-04-29 | 16.58999 | 411 | 2015-11-17 | 5.980896 |
| 134 | 2014-10-06 | 14.08504 | 273 | 2015-04-30 | 16.65604 | 412 | 2015-11-18 | 5.713577 |
| 135 | 2014-10-07 | 13.90242 | 274 | 2015-05-01 | 16.65819 | 413 | 2015-11-19 | 5.605861 |
| 136 | 2014-10-08 | 13.69615 | 275 | 2015-05-04 | 16.56033 | 414 | 2015-11-20 | 5.751264 |
| 137 | 2014-10-09 | 13.58283 | 276 | 2015-05-05 | 16.05573 | 415 | 2015-11-23 | 6.545785 |
| 138 | 2014-10-10 | 13.65108 | 277 | 2015-05-06 | 15.74715 | 416 | 2015-11-24 | 6.896734 |
| 139 | 2014-10-14 | 13.55021 | 278 | 2015-05-07 | 15.8071 | 417 | 2015-11-25 | 6.63378 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Num | Lookback  period | Spread | Num | Lookback  period | Spread | Num | Lookback  period | Spread |
| 418 | 2015-11-27 | 7.130816 | 557 | 2016-06-17 | 23.78894 | 696 | 2017-01-09 | 41.50578 |
| 419 | 2015-11-30 | 7.077851 | 558 | 2016-06-20 | 24.06423 | 697 | 2017-01-10 | 41.50021 |
| 420 | 2015-12-01 | 7.413885 | 559 | 2016-06-21 | 23.67539 | 698 | 2017-01-11 | 41.57763 |
| 421 | 2015-12-02 | 8.540916 | 560 | 2016-06-22 | 23.51037 | 699 | 2017-01-12 | 40.19785 |
| 422 | 2015-12-03 | 9.448003 | 561 | 2016-06-23 | 23.95737 | 700 | 2017-01-13 | 40.01414 |
| 423 | 2015-12-04 | 10.22803 | 562 | 2016-06-24 | 22.35089 | 701 | 2017-01-17 | 39.91306 |
| 424 | 2015-12-07 | 11.54104 | 563 | 2016-06-27 | 22.60296 | 702 | 2017-01-18 | 40.12946 |
| 425 | 2015-12-08 | 12.34806 | 564 | 2016-06-28 | 22.77447 | 703 | 2017-01-19 | 40.26954 |
| 426 | 2015-12-09 | 12.71107 | 565 | 2016-06-29 | 22.96026 | 704 | 2017-01-20 | 40.33851 |
| 427 | 2015-12-10 | 13.01813 | 566 | 2016-06-30 | 23.81234 | 705 | 2017-01-23 | 39.48304 |
| 428 | 2015-12-11 | 13.78715 | 567 | 2016-07-01 | 23.62853 | 706 | 2017-01-24 | 38.57156 |
| 429 | 2015-12-14 | 14.15316 | 568 | 2016-07-05 | 23.91648 | 707 | 2017-01-25 | 38.82608 |
| 430 | 2015-12-15 | 14.82117 | 569 | 2016-07-06 | 24.36125 | 708 | 2017-01-26 | 37.60406 |
| 431 | 2015-12-16 | 15.45217 | 570 | 2016-07-07 | 24.75354 | 709 | 2017-01-27 | 37.45731 |
| 432 | 2015-12-17 | 19.15217 | 571 | 2016-07-08 | 25.05795 | 710 | 2017-01-30 | 36.88602 |
| 433 | 2015-12-18 | 20.75217 | 572 | 2016-07-11 | 25.27971 | 711 | 2017-01-31 | 36.63816 |
| 434 | 2015-12-21 | 21.51217 | 573 | 2016-07-12 | 25.68295 | 712 | 2017-02-01 | 36.3568 |
| 435 | 2015-12-22 | 21.62617 | 574 | 2016-07-13 | 26.44545 | 713 | 2017-02-02 | 35.16079 |
| 436 | 2015-12-23 | 22.36918 | 575 | 2016-07-14 | 26.34499 | 714 | 2017-02-03 | 35.02078 |
| 437 | 2015-12-24 | 22.36918 | 576 | 2016-07-15 | 27.24175 | 715 | 2017-02-06 | 35.27048 |
| 438 | 2015-12-28 | 22.39118 | 577 | 2016-07-18 | 28.06028 | 716 | 2017-02-07 | 34.9396 |
| 439 | 2015-12-29 | 22.75118 | 578 | 2016-07-19 | 28.21028 | 717 | 2017-02-08 | 34.24699 |
| 440 | 2015-12-30 | 23.49915 | 579 | 2016-07-20 | 28.98948 | 718 | 2017-02-09 | 33.3555 |
| 441 | 2015-12-31 | 23.53815 | 580 | 2016-07-21 | 30.21142 | 719 | 2017-02-10 | 33.41746 |
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| 973 | 2018-02-15 | 23.75741 | 1112 | 2018-09-05 | 16.08683 |  |  |  |

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6. [3] p. 9, paragraph. 2 [↑](#footnote-ref-6)
7. [3] p. 10, figure 2.1 [↑](#footnote-ref-7)
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