

Meeting_5_12

Peian Lu

2022-05-11

Define a color function(ignored)

Loading packages

```
library(parallel)
library(parallelMap)
library(graphics)
library(tibble)
library(ggplot2)
library(ggcorrplot)
library(mlr)

##      ParamHelpers

## Warning message: 'mlr' is in 'maintenance-only' mode since July 2019.
## Future development will only happen in 'mlr3'
## (<https://mlr3.mlr-org.com>). Due to the focus on 'mlr3' there might be
## uncaught bugs meanwhile in {mlr} - please consider switching.

library(BBmisc)

##
##      'BBmisc'

## The following object is masked from 'package:base':
##      isFALSE

library(tidyr)
library(randomForestSRC)

##
##  randomForestSRC 3.1.0
##
##  Type rfsrc.news() to see new features, changes, and bug fixes.
##

##
##      'randomForestSRC'

## The following objects are masked from 'package:mlr':
##
##      impute, subsample
```

Pre-processing

Dealing with offline dataset

```
### offline data main
data = read.csv("C:/Users/85212/Desktop/Pro-Data/online.csv", header=TRUE)
data = data[,-2] ## removing Date_time
colnames(data)[1] = 'EFT..Hours' ## Rename EFT
names(data)

## [1] "EFT..Hours"
## [2] "total.air.flow"
## [3] "vent.flow"
## [4] "vessel"
## [5] "Station.3.Loop.Temperature"
## [6] "Station.5.Loop.Temperature"
## [7] "Level.on.the.seperator"
## [8] "harvest.flow"
## [9] "pH.at.stn5"
## [10] "pH.at.stn3"
## [11] "pH.at.stn1"
## [12] "CH4.in.offgas.."
## [13] "O2.in.offgas.."
## [14] "CO2.in.offgas.."
## [15] "LEL.in.offgas.."
## [16] "dissolved.oxygen.at.stn1"
## [17] "dissolved.oxygen.at.stn2"
## [18] "dissolved.oxygen.at.stn3"
## [19] "dissolved.oxygen.at.stn4"
## [20] "dissolved.oxygen.at.stn5"
## [21] "methane.flow.stn1"
## [22] "methane.flow.stn2"
## [23] "methane.flow.stn3"
## [24] "methane.flow.stn4"
## [25] "methane.flow.stn5"
## [26] "oxygen.flow.stn1"
## [27] "oxygen.flow.stn2"
## [28] "oxygen.flow.stn3"
## [29] "oxygen.flow.stn4"
## [30] "oxygen.flow.stn5"
## [31] "NH3.online.reading"
## [32] "optical.density"
## [33] "ammonia.pump.flow.1"
## [34] "ammonia.pump.flow.2"
## [35] "ammonia.pump.flow.3"
## [36] "nitrogen.flow.stn1"
## [37] "nitrogen.flow.stn2"
## [38] "Cooling.Loop.A.Broth.Return.to.Fermenter.mixer"
## [39] "Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117"
## [40] "Tempered.Water.Temperature.before.Temped.water.cooler"
## [41] "Tempered.Water.Temperature.after.Temped.water.cooler"
## [42] "Cooling.Water.Return.for.Temped.System"
## [43] "Cooling.loop.A.valve.opening.."
## [44] "Cooling.loop.B.valve.opening.."
```

```

## [45] "pump.outlet"
## [46] "pump.inlet"
## [47] "pressure.at.position.4"
## [48] "headspace.pressure"
## [49] "Pressure.at.the.end.of.the.loop"
## [50] "oxygen..pressure.to.fermentor.loop.mixture"
## [51] "methane..pressure.to.fermentor.loop.mixture"
## [52] "circulation.pump"
## [53] "End.of.the.loop.control.valve.output.."
## [54] "partial.pressure..DP."
## [55] "Nitric.acid.flow"
## [56] "phosphoric.acid.flow"
## [57] "sodium.hydroxide.flow"
## [58] "trace.elements.flow"
## [59] "ferrus.sulphate.flow"
## [60] "calcium.chloride.flow"
## [61] "magnesium.potassium.flow"
## [62] "spare.dosing.pump.flow"
## [63] "KOH.flow"
## [64] "Nitric.acid.totaliser"
## [65] "phosphoric.acid.totaliser"
## [66] "sodium.hydroxide.totaliser"
## [67] "trace.elements.totaliser"
## [68] "ferrous.sulphate.totaliser"
## [69] "calcium.chloride.totaliser"
## [70] "magnesium.potassium.totaliser"
## [71] "spare.dosing.pump.totaliser"
## [72] "KOH.totaliser"
## [73] "ammonia.totaliser"
## [74] "Methane.totaliser"
## [75] "oxygen.totaliser"
## [76] "Fermentor.fliud.to.ammonia...OD.meter.L.h"

ac = read.csv( "C:/Users/85212/Desktop/Pro-Data/acids.csv" ,header=TRUE)
#names(ac) = c( 'Date',names(ac)[-1] )

```

Merging by Cubic Spline Interpolation. Selecting ‘rump up’ phrase, named by **data1**

```

x = ac$EFT
y = ac$acetic
x_out = data$EFT..Hours
interpolated_acetic = spline(x = x ,y = y , xout = x_out )
data1 = cbind(data, interpolated_acetic=interpolated_acetic$y)
data1 = dplyr:: filter( data1 , EFT..Hours < 360)

```

Removing constant and negative values

```

data1 = data1[complete.cases(data1) ,]
data1$interpolated_acetic[ which(data1$interpolated_acetic < 0 )] = 0
remove_col = c()
for (j in 1:dim(data1)[2] )
{

```

```

if ( mean(data1[,j]) < 0.01 | min(data1[,j]) == mean(data1[,j]) )
remove_col = c(remove_col , j)
else
{
  wrong_row = which(data1[,j] < 0 )
  data1[wrong_row , j] = 0
}

}

data1 = data1[,-remove_col]
summary(data1)

##      EFT..Hours      total.air.flow      vent.flow      vessel
##  Min.   : 0.00   Min.   :347.4   Min.   :442.6   Min.   :43.70
##  1st Qu.: 89.92  1st Qu.:543.5   1st Qu.:696.3   1st Qu.:45.00
##  Median :179.83  Median :550.6   Median :703.4   Median :45.10
##  Mean   :179.84  Mean   :552.3   Mean   :705.0   Mean   :45.13
##  3rd Qu.:269.75  3rd Qu.:558.5   3rd Qu.:711.5   3rd Qu.:45.20
##  Max.   :359.83  Max.   :638.3   Max.   :770.7   Max.   :46.20
## Station.3.Loop.Temperature Station.5.Loop.Temperature Level.on.the.seperator
##  Min.   :43.80          Min.   :43.70          Min.   :33.70
##  1st Qu.:45.10         1st Qu.:45.10         1st Qu.:39.80
##  Median :45.20         Median :45.20         Median :40.10
##  Mean   :45.19         Mean   :45.15         Mean   :40.17
##  3rd Qu.:45.30         3rd Qu.:45.20         3rd Qu.:40.40
##  Max.   :46.20          Max.   :46.20          Max.   :48.10
##      harvest.flow      pH.at.stn5      pH.at.stn3      pH.at.stn1
##  Min.   :0.0000  Min.   :5.800   Min.   :5.800   Min.   :5.700
##  1st Qu.:0.3000  1st Qu.:6.000   1st Qu.:6.000   1st Qu.:6.100
##  Median :0.3000  Median :6.100   Median :6.100   Median :6.200
##  Mean   :0.2828  Mean   :6.074   Mean   :6.082   Mean   :6.159
##  3rd Qu.:0.3000  3rd Qu.:6.100   3rd Qu.:6.100   3rd Qu.:6.200
##  Max.   :0.5000  Max.   :6.300   Max.   :6.400   Max.   :6.400
##  CH4.in.offgas..  O2.in.offgas.. CO2.in.offgas.. LEL.in.offgas..
##  Min.   :0.0000  Min.   :20.40   Min.   :0.0000  Min.   : 0.000
##  1st Qu.:0.1000  1st Qu.:20.80   1st Qu.:0.8000  1st Qu.: 3.300
##  Median :0.2000  Median :20.80   Median :1.1000  Median : 5.300
##  Mean   :0.2076  Mean   :20.83   Mean   :0.9947  Mean   : 5.719
##  3rd Qu.:0.3000  3rd Qu.:20.90   3rd Qu.:1.3000  3rd Qu.: 7.600
##  Max.   :0.6000  Max.   :21.30   Max.   :1.6000  Max.   :22.300
##  dissolved.oxygen.at.stn1 dissolved.oxygen.at.stn2 dissolved.oxygen.at.stn3
##  Min.   : 0.0000   Min.   : 0.000   Min.   : 0.000
##  1st Qu.: 0.1000   1st Qu.: 0.800   1st Qu.: 0.400
##  Median : 0.6000   Median : 1.600   Median : 2.200
##  Mean   : 0.5688   Mean   : 2.005   Mean   : 2.322
##  3rd Qu.: 0.9000   3rd Qu.: 3.200   3rd Qu.: 3.800
##  Max.   :21.2000   Max.   :21.200   Max.   :12.000
##  dissolved.oxygen.at.stn4 dissolved.oxygen.at.stn5 methane.flow.stn1
##  Min.   : 0.000   Min.   : 0.000   Min.   : 0.000
##  1st Qu.: 1.500   1st Qu.: 0.100   1st Qu.: 2.400
##  Median : 2.700   Median : 0.400   Median : 2.800
##  Mean   : 2.872   Mean   : 1.166   Mean   : 3.346
##  3rd Qu.: 4.100   3rd Qu.: 2.000   3rd Qu.: 4.400
##  Max.   :14.000   Max.   :56.200   Max.   : 7.500

```

```

## methane.flow.stn2 methane.flow.stn3 methane.flow.stn4 methane.flow.stn5
## Min.    :0.0000   Min.    :0.000   Min.    :0.000   Min.    :0.000
## 1st Qu.:0.0000   1st Qu.:1.200   1st Qu.:0.000   1st Qu.:1.200
## Median :0.0000   Median :1.600   Median :2.200   Median :1.200
## Mean    :0.8984   Mean    :1.821   Mean    :1.537   Mean    :1.234
## 3rd Qu.:2.0000   3rd Qu.:2.500   3rd Qu.:2.200   3rd Qu.:1.600
## Max.    :8.5000   Max.    :4.200   Max.    :4.400   Max.    :2.200
## oxygen.flow.stn1 oxygen.flow.stn2 oxygen.flow.stn3 oxygen.flow.stn4
## Min.    :0.000   Min.    :0.000   Min.    :0.000   Min.    :0.000
## 1st Qu.:3.100   1st Qu.:0.000   1st Qu.:1.700   1st Qu.:0.300
## Median :3.600   Median :0.000   Median :2.100   Median :3.000
## Mean    :4.454   Mean    :1.211   Mean    :2.483   Mean    :2.265
## 3rd Qu.:6.300   3rd Qu.:2.800   3rd Qu.:3.700   3rd Qu.:3.200
## Max.    :9.800   Max.    :10.500  Max.    :4.400   Max.    :3.800
## oxygen.flow.stn5 NH3.online.reading optical.density ammonia.pump.flow.1
## Min.    :0.000   Min.    :0.00   Min.    :0.100  Min.    :0.000
## 1st Qu.:1.900   1st Qu.:13.40  1st Qu.:1.000  1st Qu.:0.900
## Median :1.900   Median :19.60  Median :1.100  Median :1.100
## Mean    :1.937   Mean    :22.13  Mean    :1.106  Mean    :1.064
## 3rd Qu.:2.500   3rd Qu.:27.00  3rd Qu.:1.300  3rd Qu.:1.300
## Max.    :3.100   Max.    :68.90  Max.    :1.800  Max.    :1.900
## ammonia.pump.flow.2 Cooling.Loop.A.Broth.Return.to.Fermenter.mixer
## Min.    :0.0000   Min.    :40.00
## 1st Qu.:0.4000   1st Qu.:41.70
## Median :0.5000   Median :42.00
## Mean    :0.4364   Mean    :42.18
## 3rd Qu.:0.6000   3rd Qu.:42.40
## Max.    :1.0000   Max.    :45.90
## Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117
## Min.    :40.20
## 1st Qu.:41.70
## Median :42.10
## Mean    :42.23
## 3rd Qu.:42.45
## Max.    :46.20
## Tempered.Water.Temperature.before.Temped.water.cooler
## Min.    :42.10
## 1st Qu.:42.90
## Median :43.10
## Mean    :43.19
## 3rd Qu.:43.30
## Max.    :46.10
## Tempered.Water.Temperature.after.Temped.water.cooler
## Min.    : 36.50
## 1st Qu.: 41.30
## Median : 41.60
## Mean    : 41.95
## 3rd Qu.: 42.00
## Max.    :202.30
## Cooling.Water.Return.for.Temped.System Cooling.loop.A.valve.opening..
## Min.    :18.40           Min.    : 10.30
## 1st Qu.:35.10           1st Qu.:100.00
## Median :36.20           Median :100.00
## Mean    :35.52           Mean    : 97.01

```

```

## 3rd Qu.:36.80          3rd Qu.:100.00
## Max.   :39.10          Max.   :100.00
## Cooling.loop.B.valve.opening.. pump.outlet      pump.inlet
## Min.   : 11.0           Min.   :3.000    Min.   :0.6000
## 1st Qu.: 99.2           1st Qu.:3.100    1st Qu.:0.6000
## Median :100.0           Median :3.100    Median :0.7000
## Mean   : 92.5           Mean   :3.097    Mean   :0.6586
## 3rd Qu.:100.0           3rd Qu.:3.100    3rd Qu.:0.7000
## Max.   :100.0           Max.   :3.100    Max.   :0.7000
## pressure.at.position.4 headspace.pressure Pressure.at.the.end.of.the.loop
## Min.   :2.3             Min.   :0.3000   Min.   :1.900
## 1st Qu.:2.4             1st Qu.:0.4000   1st Qu.:2.000
## Median :2.4             Median :0.4000   Median :2.000
## Mean   : 2.4             Mean   :0.3999   Mean   :2.015
## 3rd Qu.:2.4             3rd Qu.:0.4000   3rd Qu.:2.000
## Max.   :2.4             Max.   :0.4000   Max.   :2.100
## oxygen..pressure.to.fermentor.loop.mixture
## Min.   :7.000
## 1st Qu.:7.100
## Median :7.100
## Mean   :7.133
## 3rd Qu.:7.200
## Max.   :7.300
## methane..pressure.to.fermentor.loop.mixture partial.pressure..DP.
## Min.   :6.40              Min.   :1.000
## 1st Qu.:6.60              1st Qu.:1.000
## Median :6.60              Median :1.000
## Mean   : 6.61              Mean   :1.005
## 3rd Qu.:6.60              3rd Qu.:1.000
## Max.   :6.80              Max.   :1.100
## phosphoric.acid.flow sodium.hydroxide.flow trace.elements.flow
## Min.   :0.000             Min.   :0.0000   Min.   :0.000
## 1st Qu.:0.400             1st Qu.:0.0000   1st Qu.:0.200
## Median :0.700             Median :0.0000   Median :0.400
## Mean   : 0.597             Mean   :0.7028   Mean   :0.373
## 3rd Qu.:0.700             3rd Qu.:0.0000   3rd Qu.:0.600
## Max.   :1.300             Max.   :7.8000   Max.   :0.900
## ferrus.sulphate.flow calcium.chloride.flow magnesium.potassium.flow
## Min.   :0.0000            Min.   :0.0000   Min.   :0.000
## 1st Qu.:0.7000            1st Qu.:0.7000   1st Qu.:1.500
## Median :0.9000            Median :0.8000   Median :1.900
## Mean   : 0.9464            Mean   :0.7034   Mean   :1.763
## 3rd Qu.:1.2000            3rd Qu.:0.8000   3rd Qu.:2.100
## Max.   :1.9000            Max.   :1.2000   Max.   :3.300
## spare.dosing.pump.flow phosphoric.acid.totaliser sodium.hydroxide.totaliser
## Min.   :0.000              Min.   :  3.90    Min.   :  1.00
## 1st Qu.:1.400              1st Qu.: 42.85   1st Qu.: 51.35
## Median :1.500              Median :104.10   Median :107.10
## Mean   : 1.483              Mean   :102.15   Mean   :108.78
## 3rd Qu.:1.700              3rd Qu.:152.10   3rd Qu.:162.10
## Max.   :6.600              Max.   :229.10   Max.   :239.10
## trace.elements.totaliser ferrous.sulphate.totaliser calcium.chloride.totaliser
## Min.   :218.1               Min.   :635.1    Min.   :476.1
## 1st Qu.:248.1               1st Qu.:705.1    1st Qu.:515.1

```

```

## Median :273.1          Median :788.1          Median :587.1
## Mean   :275.6          Mean   :786.7          Mean   :587.7
## 3rd Qu.:301.1          3rd Qu.:856.1          3rd Qu.:651.6
## Max.   :356.1          Max.   :979.1          Max.   :737.1
## magnesium.potassium.totalier spare.dosing.pump.totaliser ammonia.totalier
## Min.   :1087             Min.   :1013            Min.   :0.000
## 1st Qu.:1171             1st Qu.:1100           1st Qu.:1.200
## Median :1338             Median :1248           Median :1.600
## Mean   :1348             Mean   :1261           Mean   :1.509
## 3rd Qu.:1502             3rd Qu.:1406           3rd Qu.:1.900
## Max.   :1727             Max.   :1615           Max.   :2.900
## Methane.totalier oxygen.totaliser Fermentor.fliud.to.ammonia...OD.meter.L.h
## Min.   : 0.000   Min.   : 0.00   Min.   : 0.00
## 1st Qu.: 7.400   1st Qu.:10.50   1st Qu.: 38.80
## Median : 9.500   Median :13.50   Median : 42.10
## Mean   : 8.806   Mean   :12.31   Mean   : 41.86
## 3rd Qu.:10.700   3rd Qu.:15.20   3rd Qu.: 45.70
## Max.   :14.900   Max.   :24.70   Max.   :123.10
## interpolated_acetic
## Min.   :0.000
## 1st Qu.:1.427
## Median :2.698
## Mean   :3.505
## 3rd Qu.:5.399
## Max.   :9.663

```

Imputation

```

imputeMethod = imputeLearner("regr.rpart")
data1Imp = impute(as.data.frame(data1), classes = list(numeric = imputeMethod) )

```

Plot

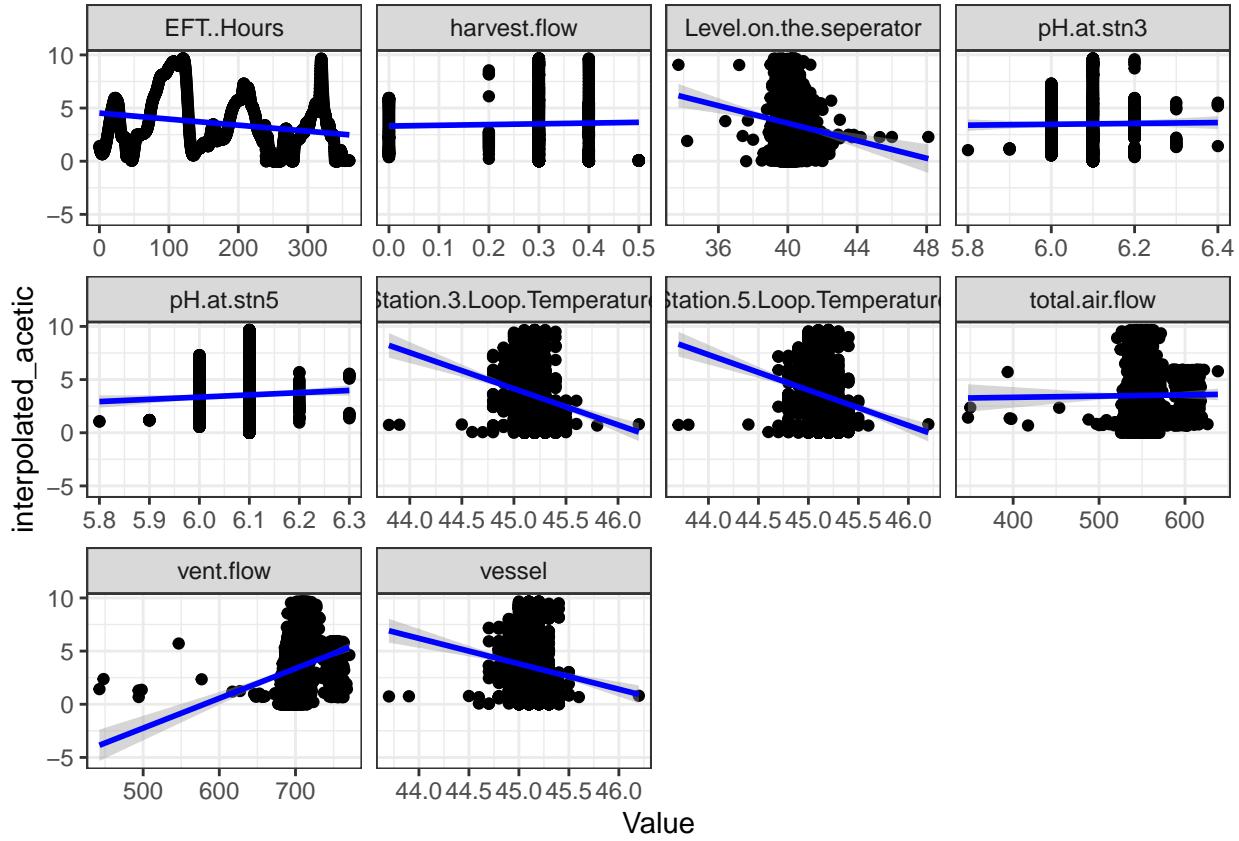
Individual Plot

```

data1_gather = gather(data1[,c(1:10,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```

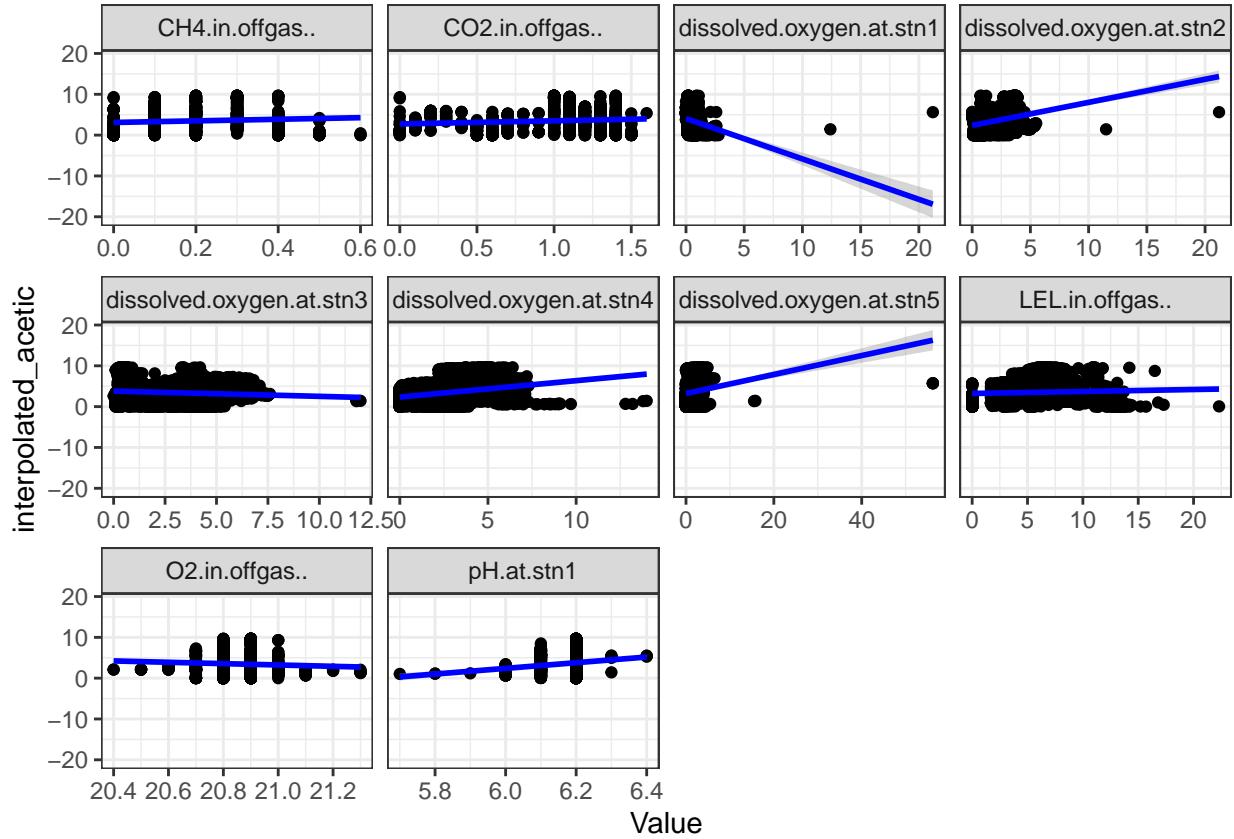


```

data1_gather = gather(data1[,c(11:20,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```

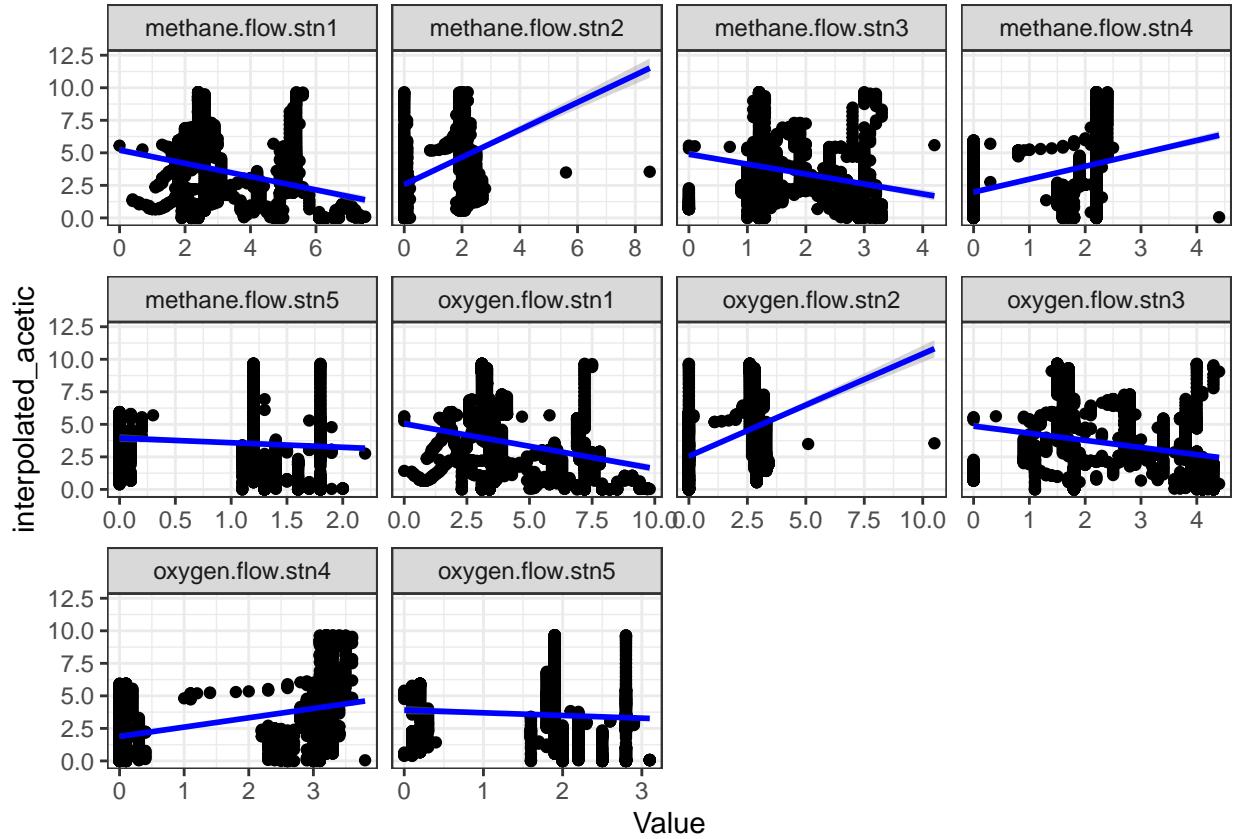


```

data1_gather = gather(data1[,c(21:30,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```

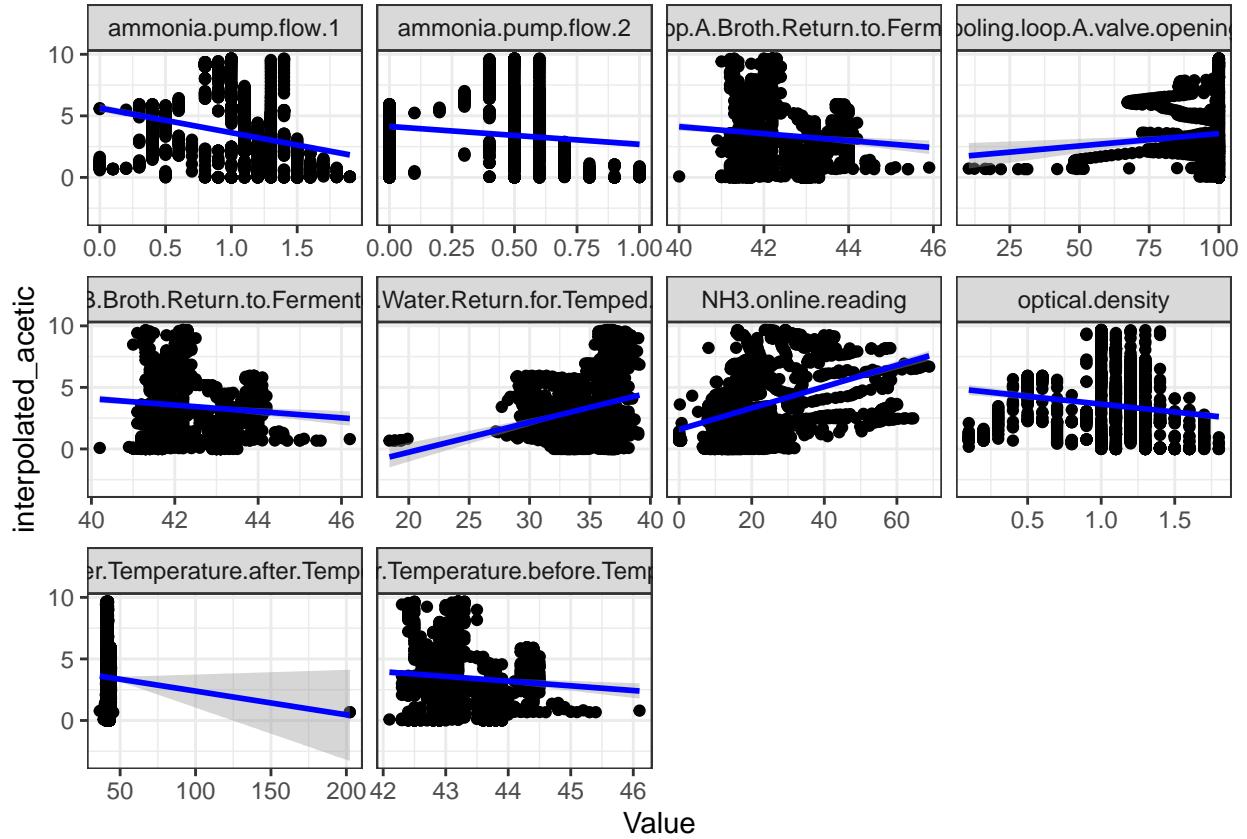


```

data1_gather = gather(data1[,c(31:40,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```

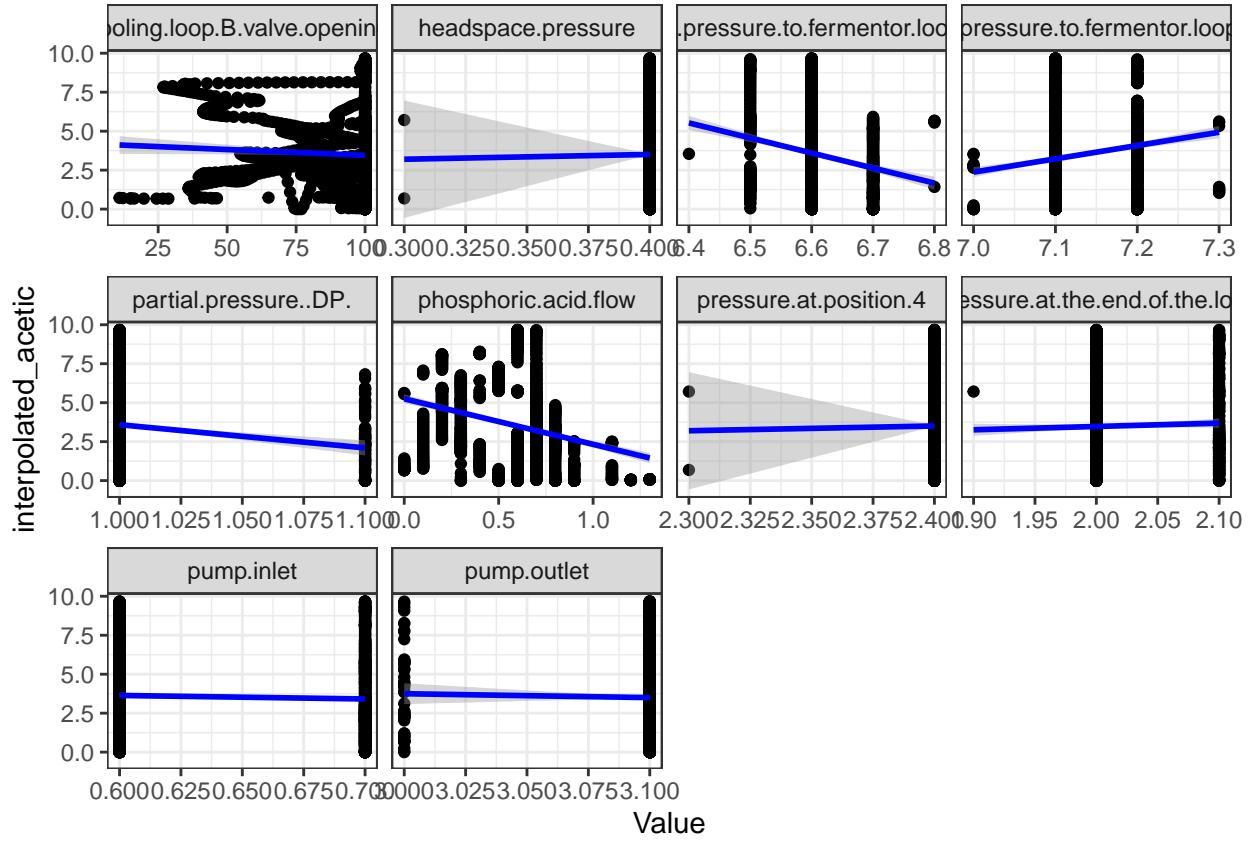


```

data1_gather = gather(data1[,c(41:50,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```

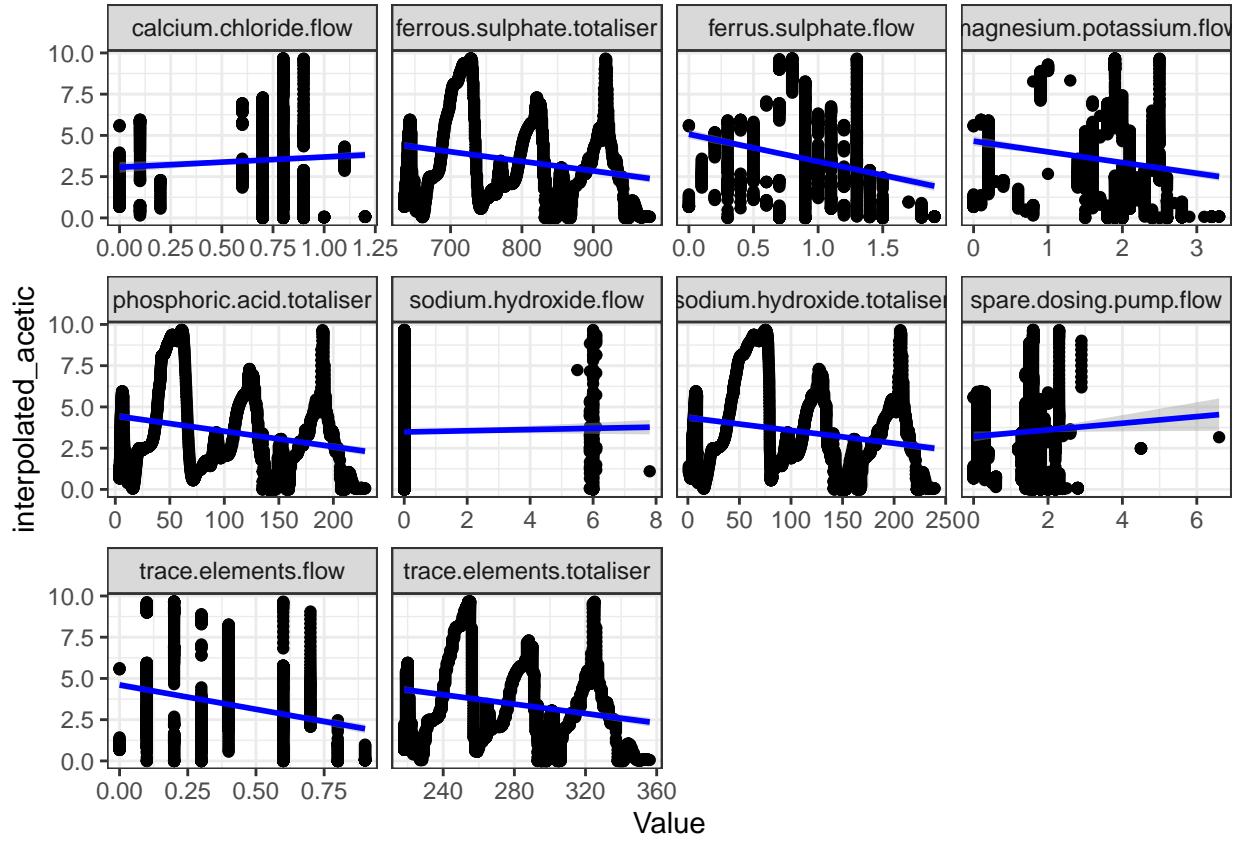


```

data1_gather = gather(data1[,c(51:60,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```

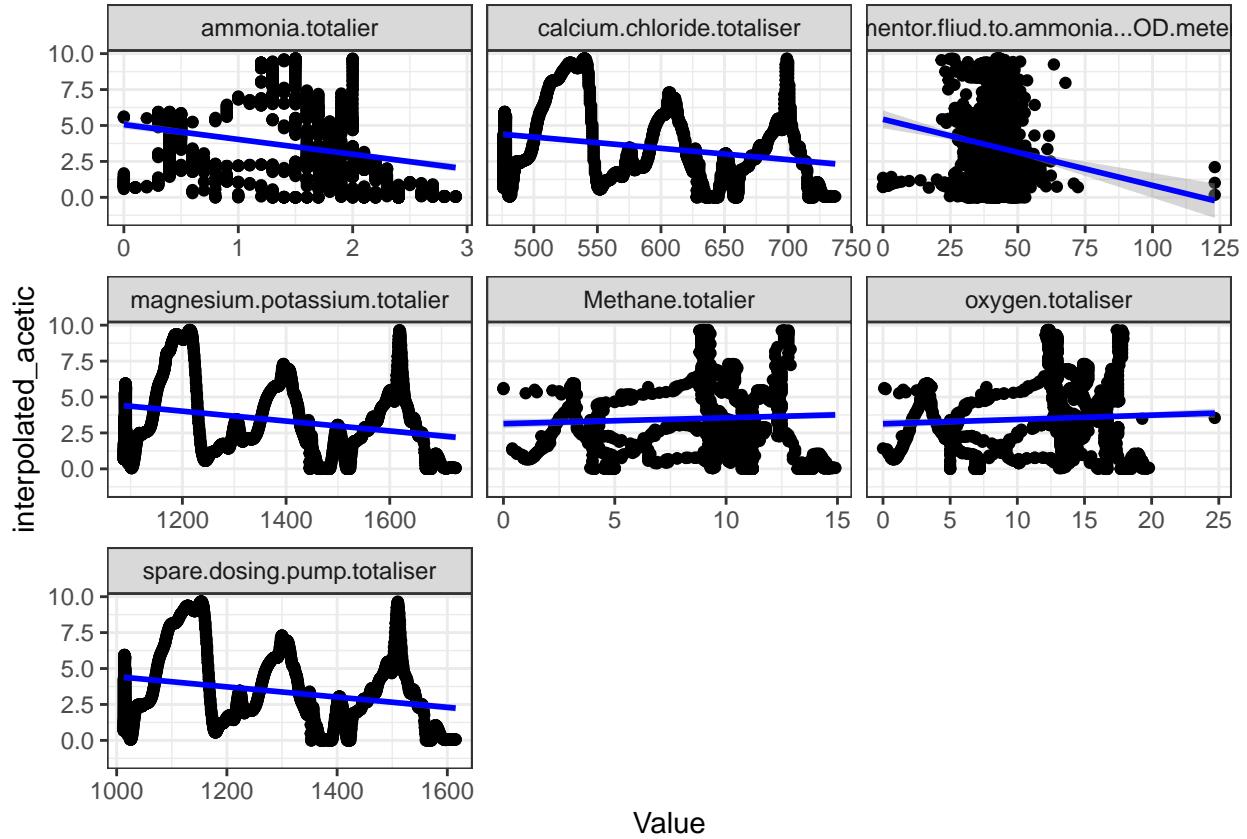


```

data1_gather = gather(data1[,c(61:67,68)], key = "Variable",
value = "Value", -c( interpolated_acetic ) )
ggplot(data1_gather, aes(Value, interpolated_acetic)) +
facet_wrap(~ Variable, scale = "free_x") +
geom_point() +
geom_smooth(method = "lm", col = "blue") +
theme_bw()

## `geom_smooth()` using formula 'y ~ x'

```



Building Lasso

Define Task

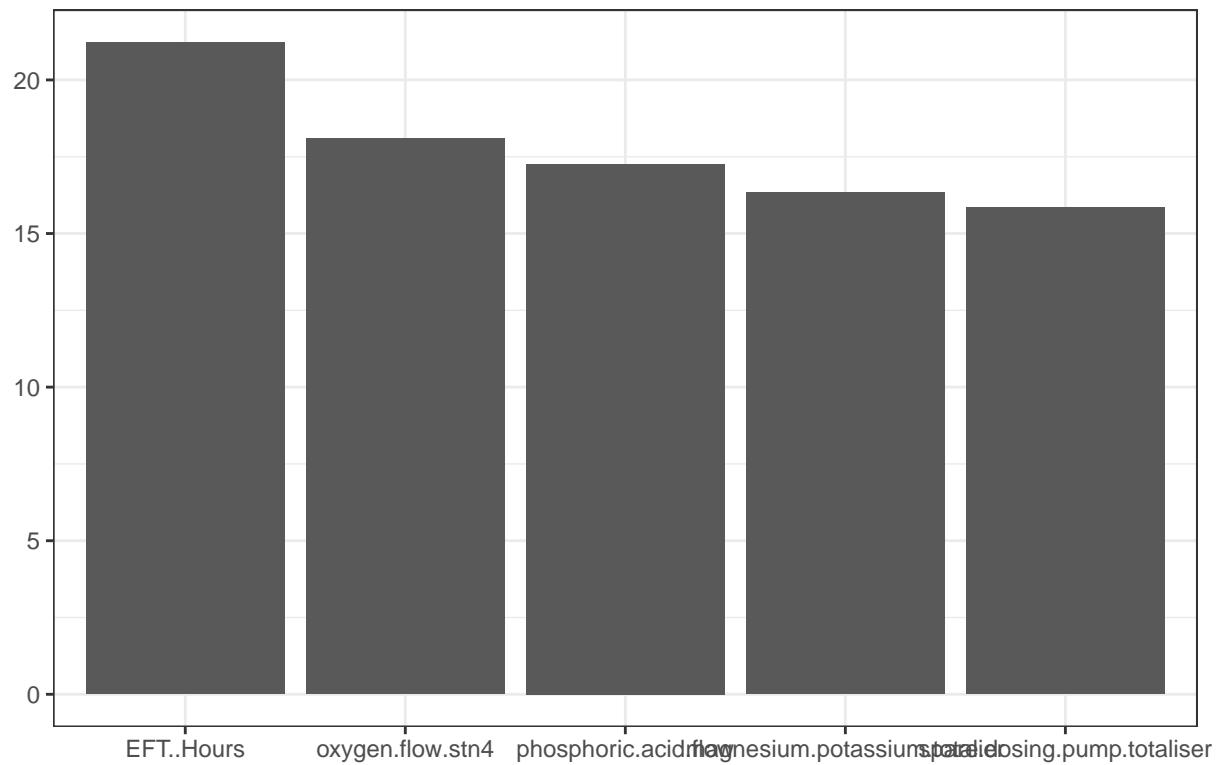
```
task = makeRegrTask( data1, target = "interpolated_acetic" , id = 'lasso')
print(task)
```

```
## Supervised task: lasso
## Type: regr
## Target: interpolated_acetic
## Observations: 2159
## Features:
##      numerics      factors      ordered functionals
##          67             0                 0             0
## Missings: FALSE
## Has weights: FALSE
## Has blocking: FALSE
## Has coordinates: FALSE
```

Features importance by random forest

```
filterVals = generateFilterValuesData(task , method = "randomForest_importance")
plotFilterValues(filterVals , n.show = 5) +
theme_bw()
```

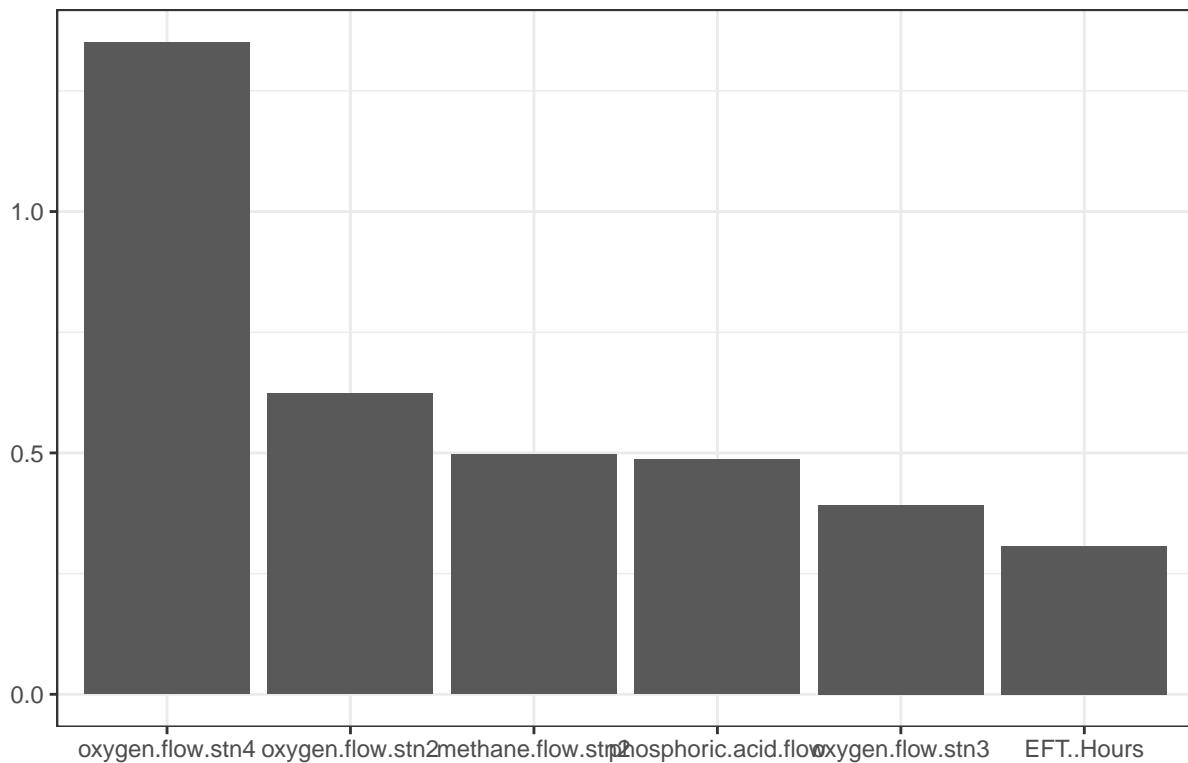
lasso (5 out of 67 features), filter = randomForest_importance



Generating and plotting filter values by correlation

```
filterVals = generateFilterValuesData(task)
plotFilterValues(filterVals , n.show = 6) + theme_bw()
```

lasso (6 out of 67 features), filter = randomForestSRC_importance



Pre-required function (ignored)

```
getTrainingInfo = function(x) {
  attr(x$learner.model, "mlr.train.info") # attr(x, "mlr.train.info")
}

attachTrainingInfo = function(x, info) {
  attr(x, "mlr.train.info") = info
  x
}

getFixDataInfo = function(data, restore.levels = FALSE, factors.to.dummies = FALSE, ordered.to.int = FALSE) {
  cl = vapply(data, getClass)
  factors = lapply(data[cl == "factor"], levels)
  ordered = lapply(data[cl == "ordered"], levels)

  makeS3Obj("FixDataInfo",
            factors = factors,
            ordered = ordered,
            restore.levels = restore.levels,
            factors.to.dummies = factors.to.dummies && length(factors) > 0L,
            ordered.to.int = ordered.to.int && length(ordered) > 0L
  )
}
```

```

fixDataForLearner = function(data, info) {

  cn = c(names(info$factors), names(info$ordered))
  not.found = which.first(cn %nin% names(data))
  if (length(not.found) > 0L) {
    stopf("Column '%s' found in info, but not in new data", cn[not.found])
  }

  if (info$restore.levels) {
    if (!info$factors.to.dummies && length(info$factors) > 0L) {
      cols = names(info$factors)
      data[cols] = Map(factor, x = data[cols], levels = info$factors)
    }
    if (!info$ordered.to.int && length(info$ordered) > 0L) {
      cols = names(info$ordered)
      data[cols] = Map(factor, x = data[cols], levels = info$ordered, ordered = TRUE)
    }
  }

  if (info$factors.to.dummies) {
    cols = names(info$factors)
    new.cols = Map(function(x, lvls) {
      as.data.frame(setNames(lapply(lvls, "==" , x), lvls))
    }, x = data[cols], lvls = info$factors)
    data = cbind(dropNamed(data, cols), do.call(cbind, new.cols))
  }

  if (info$ordered.to.int) {
    cols = names(info$ordered)
    data[cols] = lapply(data[cols], as.integer)
  }

  data
}

```

Fix data for leaner

```

makeRLearner.regr.trunc.lasso = function() {
  makeRLearnerRegr(
    cl = "regr.trunc.lasso",
    package = "glmnet",
    par.set = makeParamSet(
      makeDiscreteLearnerParam(id = "family", values = c("gaussian", "poisson"), default =
        "gaussian"),
      makeNumericLearnerParam(id = "alpha", default = 1, lower = 0, upper = 1),
      makeNumericLearnerParam(id = "s", lower = 0, when = "predict")
    ),
    properties = c("numerics"),
    par.vals = list(s = 0.01),
    name = "GLM with Lasso or Elasticnet Regularization",
    short.name = "glmnet",
    callees = c("glmnet", "glmnet.control", "predict.glmnet")
  )
}

```

```

}

trainLearner.regr.trunc.lasso = function (.learner, .task, .subset, ...)
{
  d = getTaskData(.task, .subset, target.extra = TRUE)
  info = getFixDataInfo(d$data, factors.to.dummies = TRUE, ordered.to.int = TRUE)
  args = c(list(x = as.matrix(fixDataForLearner(d$data, info)), y = d$target), list(...))
  glmnet::glmnet.control(factory = TRUE)
  saved.ctrl = glmnet::glmnet.control()
  is.ctrl.arg = names(args) %in% names(saved.ctrl)
  if (any(is.ctrl.arg)) {
    on.exit(glmnet::glmnet.control(factory = TRUE))
    do.call(glmnet::glmnet.control, args[is.ctrl.arg])
    args = args[!is.ctrl.arg]
  }
  attachTrainingInfo(do.call(glmnet::cv.glmnet, args), info)
}

predictLearner.regr.trunc.lasso = function (.learner, .model, .newdata, ...)
{
  info = getTrainingInfo(.model)
  .newdata = as.matrix(fixDataForLearner(.newdata, info))
  mins = .model$learner.model$lambda.min
  print(mins)
  p = predict(.model$learner.model, newx = .newdata, s = mins)
  index = which( p < 0 )
  p[index] = 0
  return (as.vector(p))
}

```

Define New learner getLearnerParamSet(makeLearner("regr.glmnet"))
 class(makeLearner(cl = "regr.trunc.lasso"))

Training

With truncation

```

parallelStartSocket(cpus = detectCores())

## Starting parallelization in mode=socket with cpus=16.
parallelLibrary("mlr")

## Loading packages on slaves for mode socket: mlr
parallelLibrary("BBmisc")

## Loading packages on slaves for mode socket: BBmisc
parallelSource("new_learner_support.R")

## Sourcing files on master: new_learner_support.R
## Sourcing files on slaves: new_learner_support.R
lasso = makeLearner("regr.trunc.lasso", alpha = 1, id = "lasso" )
lassoParamSpace = makeParamSet(

```

```

makeNumericParam("s", lower = 0, upper = 0.1))

cvForTuning = makeResampleDesc("RepCV", folds = 5, reps = 2)
randSearch = makeTuneControlRandom(maxit = 2)

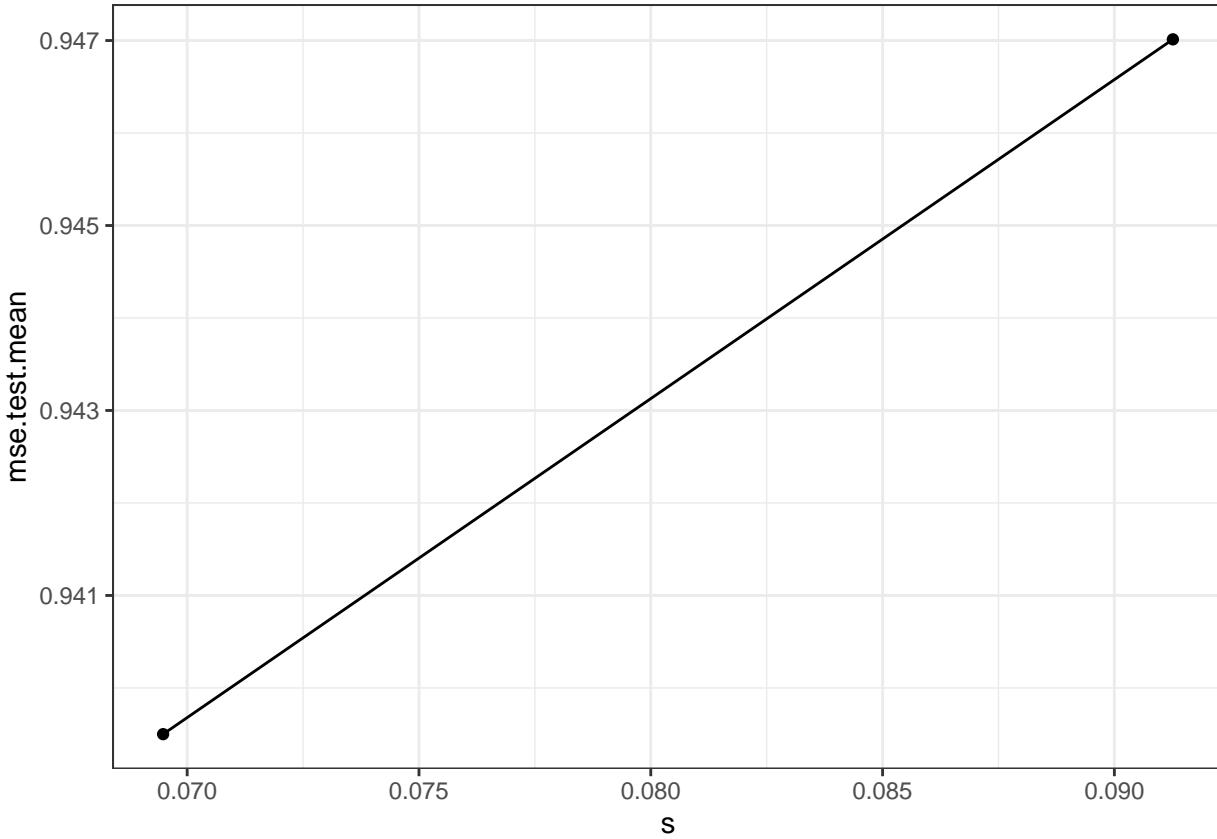
tunedLassoPars = tuneParams(lasso, task = task,
resampling = cvForTuning,
par.set = lassoParamSpace,
control = randSearch)

## [Tune] Started tuning learner lasso for parameter set:
##      Type len Def  Constr Req Tunable Trafo
## s numeric   -   0 to 0.1   -    TRUE   -
## With control class: TuneControlRandom
## Imputation value: Inf
## Exporting objects to slaves for mode socket: .mlr.slave.options
## Mapping in parallel: mode = socket; level = mlr.tuneParams; cpus = 16; elements = 2.
## [Tune] Result: s=0.0695 : mse.test.mean=0.9395002
parallelStop()

## Stopped parallelization. All cleaned up.
tunedLassoPars

## Tune result:
## Op. pars: s=0.0695
## mse.test.mean=0.9395002
lassoTuningData = generateHyperParsEffectData(tunedLassoPars)
plotHyperParsEffect(lassoTuningData, x = "s", y = "mse.test.mean",
plot.type = "line") +
theme_bw()

```

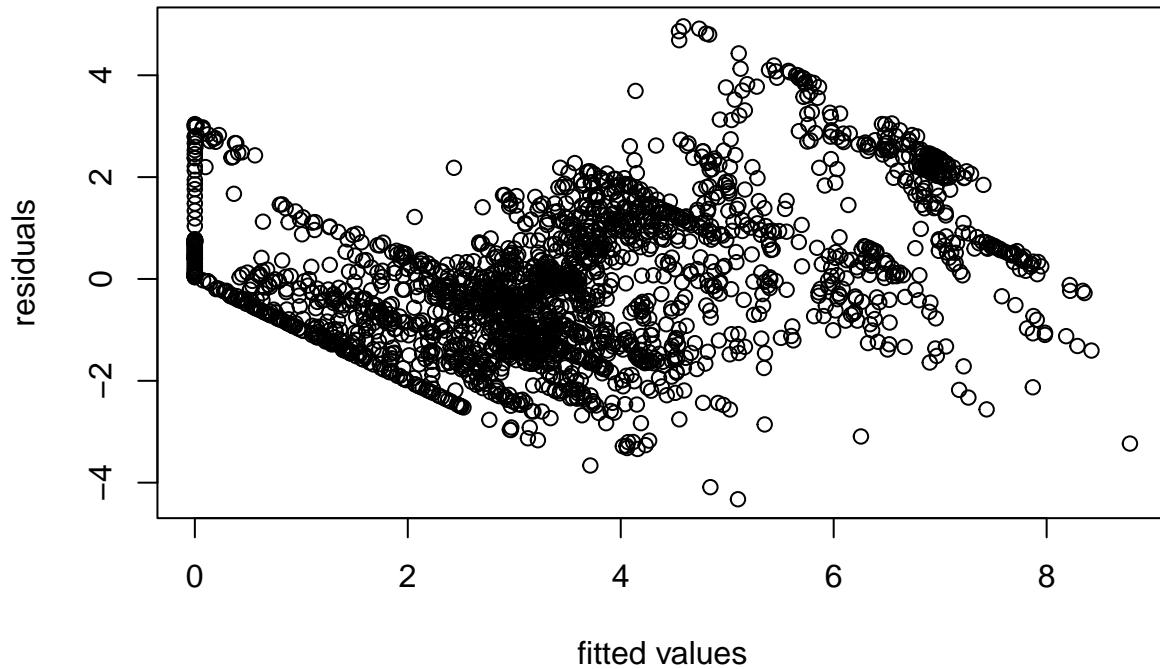


Without truncation

```

lasso_normal = makeLearner("regr.glmnet", alpha = 1, id = "lasso")
tunedLasso = setHyperPars(lasso_normal, par.vals = list(s = 0.09358278) )
tunedLassoModel = train(tunedLasso, task)
lassoModelData = getLearnerModel(tunedLassoModel)
lassoCoefs = coef(lassoModelData, s = 0.09358278)
pred = predict(tunedLassoModel, task)
index = which(pred$data$response < 0)
pred$data$response[index] = 0
plot( pred$data$response ,(pred$data$truth-pred$data$response) , xlab = 'fitted values' , ylab='residuals')

```



```
lassoCoefs
```

```
## 68 x 1 sparse Matrix of class "dgCMatrix"
##                                     s1
## (Intercept)                 -60.130221133
## EFT..Hours                   .
## total.air.flow                .
## vent.flow                      0.016639490
## vessel                         .
## Station.3.Loop.Temperature    -0.582583514
## Station.5.Loop.Temperature    -0.283283368
## Level.on.the.seperator        .
## harvest.flow                   .
## pH.at.stn5                     .
## pH.at.stn3                     .
## pH.at.stn1                      10.414757654
## CH4.in.offgas..                  1.041975063
## O2.in.offgas..                   .
## CO2.in.offgas..                  0.662639063
## LEL.in.offgas..                  .
## dissolved.oxygen.at.stn1      -0.064234430
## dissolved.oxygen.at.stn2      .
## dissolved.oxygen.at.stn3      .
## dissolved.oxygen.at.stn4      .
## dissolved.oxygen.at.stn5                  0.082782845
## methane.flow.stn1                  .
## methane.flow.stn2                  0.004945261
```

## methane.flow.stn3	0.040910356
## methane.flow.stn4	.
## methane.flow.stn5	.
## oxygen.flow.stn1	.
## oxygen.flow.stn2	0.099988633
## oxygen.flow.stn3	.
## oxygen.flow.stn4	1.166825551
## oxygen.flow.stn5	.
## NH3.online.reading	.
## optical.density	-0.458286858
## ammonia.pump.flow.1	-2.424998113
## ammonia.pump.flow.2	.
## Cooling.Loop.A.Broth.Return.to.Fermenter.mixer	.
## Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	.
## Tempered.Water.Temperature.before.Temped.water.cooler	-0.538081043
## Tempered.Water.Temperature.after.Temped.water.cooler	.
## Cooling.Water.Return.for.Temped.System	0.032917357
## Cooling.loop.A.valve.opening..	0.036139843
## Cooling.loop.B.valve.opening..	0.003904115
## pump.outlet	.
## pump.inlet	.
## pressure.at.position.4	.
## headspace.pressure	.
## Pressure.at.the.end.of.the.loop	-0.138453070
## oxygen..pressure.to.fermentor.loop.mixture	6.699753423
## methane..pressure.to.fermentor.loop.mixture	.
## partial.pressure..DP.	.
## phosphoric.acid.flow	-4.085618449
## sodium.hydroxide.flow	.
## trace.elements.flow	-0.180923275
## ferrus.sulphate.flow	-0.712217559
## calcium.chloride.flow	.
## magnesium.potassium.flow	-0.418459731
## spare.dosing.pump.flow	0.535702741
## phosphoric.acid.totaliser	.
## sodium.hydroxide.totaliser	.
## trace.elements.totaliser	.
## ferrous.sulphate.totaliser	.
## calcium.chloride.totaliser	.
## magnesium.potassium.totaliser	.
## spare.dosing.pump.totaliser	.
## ammonia.totalier	.
## Methane.totalier	.
## oxygen.totaliser	.
## Fermentor.fliud.to.ammonia...OD.meter.L.h	.

Refit lasso by Linear Regression

Get coefficients

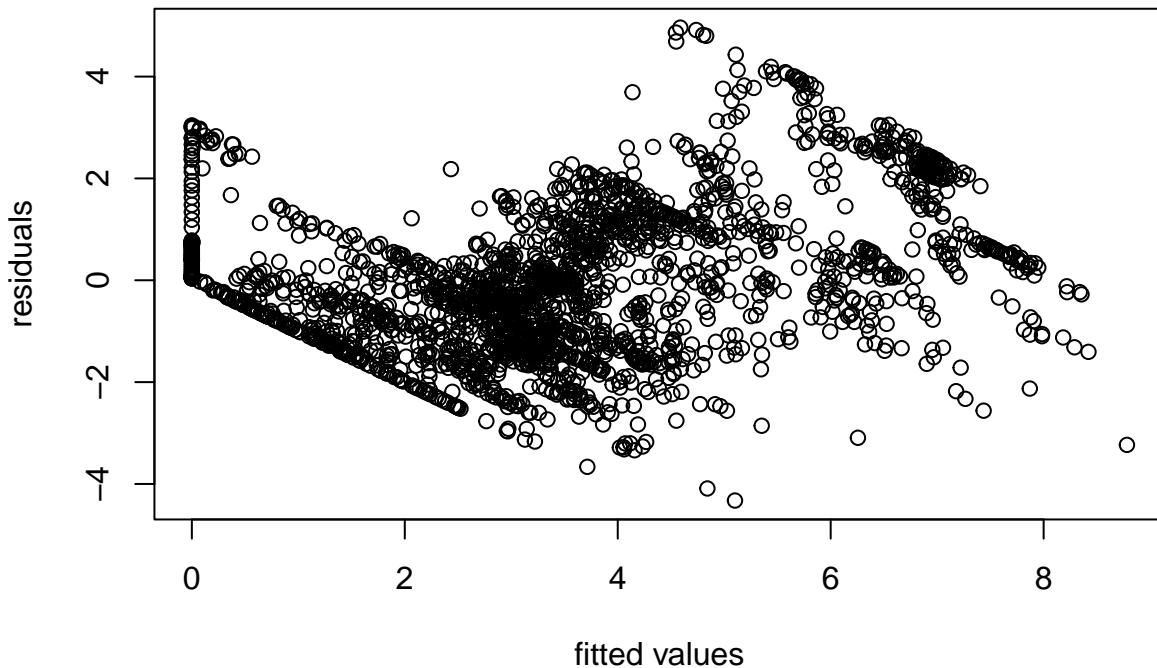
In lasso without truncation, $s = 0.09358278$. Otherwise, $s = 2.57$ with search range $\{0,10\}$ and $s = 0.8545604$ with range $\{0.1\}$. mean absolute error is 1.140247 when $s = 0.09$ mean absolute error is 0.6319 when $s = 0.85$?

```

pred = predict(tunedLassoModel, task)
index = which(pred$data$response < 0)
pred$data$response[index] = 0
plot( pred$data$response , (pred$data$truth-pred$data$response) , xlab = 'fitted values' , ylab='residual'

```

lasso without truncation



```

Mean_Error_lasso = mean( abs(pred$data$truth-pred$data$response) )
cat('mean absolute error: ', Mean_Error_lasso)

```

```
## mean absolute error: 1.140247
```

Refit regression by variables selected by Lasso

```

Coef = as.numeric( lassoCoefs)
index = which(Coef!=0)[-c(1)] ## remove EFT.h EFT.acid and intercept
variables = rownames(lassoCoefs)[index]
print(variables)

## [1] "vent.flow"
## [2] "Station.3.Loop.Temperature"
## [3] "Station.5.Loop.Temperature"
## [4] "pH.at.stn1"
## [5] "CH4.in.offgas.."
## [6] "CO2.in.offgas.."
## [7] "dissolved.oxygen.at.stn1"
## [8] "dissolved.oxygen.at.stn5"
## [9] "methane.flow.stn2"

```

```

## [10] "methane.flow.stn3"
## [11] "oxygen.flow.stn2"
## [12] "oxygen.flow.stn4"
## [13] "optical.density"
## [14] "ammonia.pump.flow.1"
## [15] "Tempered.Water.Temperature.before.Temped.water.cooler"
## [16] "Cooling.Water.Return.for.Temped.System"
## [17] "Cooling.loop.A.valve.opening.."
## [18] "Cooling.loop.B.valve.opening.."
## [19] "Pressure.at.the.end.of.the.loop"
## [20] "oxygen..pressure.to.fermentor.loop.mixture"
## [21] "phosphoric.acid.flow"
## [22] "trace.elements.flow"
## [23] "ferrus.sulphate.flow"
## [24] "magnesium.potassium.flow"
## [25] "spare.dosing.pump.flow"

names(data1)[index-1]

## [1] "vent.flow"
## [2] "Station.3.Loop.Temperature"
## [3] "Station.5.Loop.Temperature"
## [4] "pH.at.stn1"
## [5] "CH4.in.offgas.."
## [6] "CO2.in.offgas.."
## [7] "dissolved.oxygen.at.stn1"
## [8] "dissolved.oxygen.at.stn5"
## [9] "methane.flow.stn2"
## [10] "methane.flow.stn3"
## [11] "oxygen.flow.stn2"
## [12] "oxygen.flow.stn4"
## [13] "optical.density"
## [14] "ammonia.pump.flow.1"
## [15] "Tempered.Water.Temperature.before.Temped.water.cooler"
## [16] "Cooling.Water.Return.for.Temped.System"
## [17] "Cooling.loop.A.valve.opening.."
## [18] "Cooling.loop.B.valve.opening.."
## [19] "Pressure.at.the.end.of.the.loop"
## [20] "oxygen..pressure.to.fermentor.loop.mixture"
## [21] "phosphoric.acid.flow"
## [22] "trace.elements.flow"
## [23] "ferrus.sulphate.flow"
## [24] "magnesium.potassium.flow"
## [25] "spare.dosing.pump.flow"

reg = lm(interpolated_acetic~, data1[, c(index-1, 68)] )
summary(reg)

##
## Call:
## lm(formula = interpolated_acetic ~ ., data = data1[, c(index -
##       1, 68)])
##
## Residuals:
##      Min       1Q   Median       3Q      Max

```

```

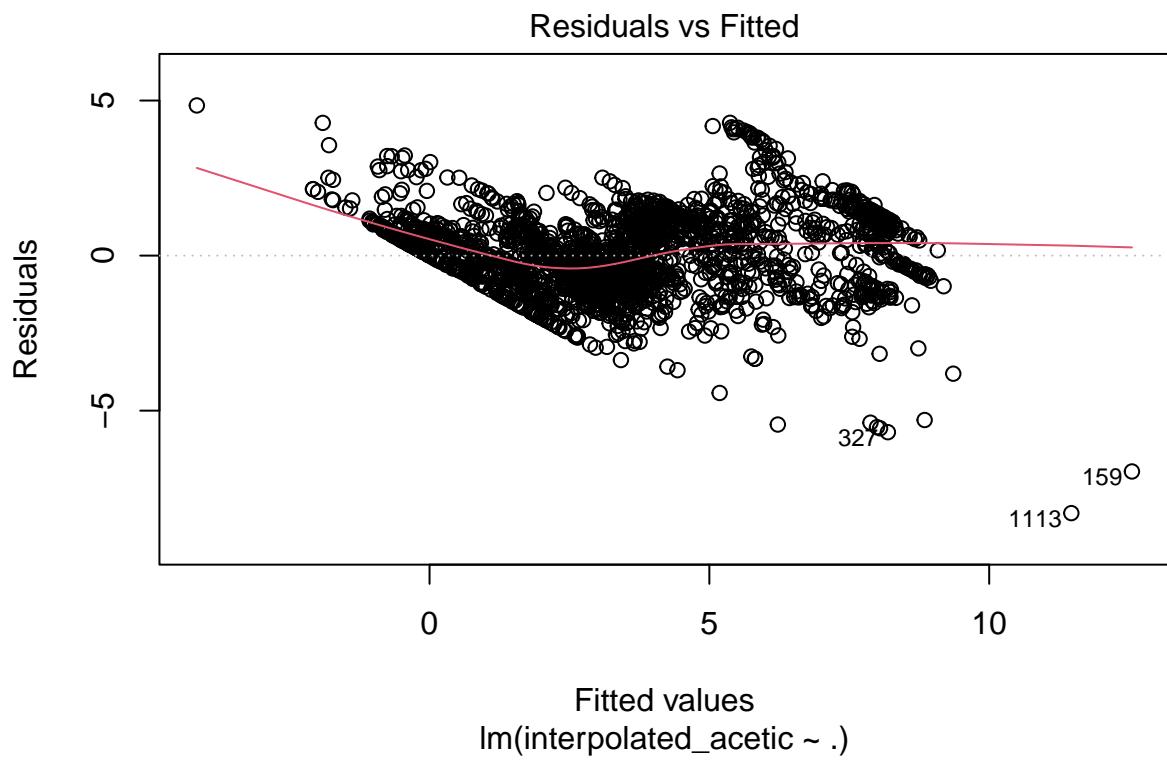
## -8.3046 -0.8194 -0.1022  0.8387  4.8417
##
## Coefficients:
##                               Estimate Std. Error
## (Intercept)                -68.029082 14.252622
## vent.flow                   0.021376  0.001633
## Station.3.Loop.Temperature -0.369538  0.534972
## Station.5.Loop.Temperature  0.140494  0.515021
## pH.at.stn1                  13.151131  0.651751
## CH4.in.offgas..               1.502131  0.329177
## CO2.in.offgas..              0.871683  0.253492
## dissolved.oxygen.at.stn1    -0.108472  0.049783
## dissolved.oxygen.at.stn5    0.095021  0.011859
## methane.flow.stn2            -0.689824  0.324865
## methane.flow.stn3            1.450843  0.117210
## oxygen.flow.stn2              1.114883  0.251531
## oxygen.flow.stn4              0.745869  0.066276
## optical.density              -1.424365  0.181767
## ammonia.pump.flow.1          -3.298348  0.179117
## Tempered.Water.Temperature.before.Temped.water.cooler -2.006279  0.261801
## Cooling.Water.Return.for.Temped.System                 -0.021396  0.028175
## Cooling.loop.A.valve.opening..                         0.008705  0.005919
## Cooling.loop.B.valve.opening..                         0.025108  0.003664
## Pressure.at.the.end.of.the.loop                      -2.601107  0.798244
## oxygen.pressure.to.fermentor.loop.mixture           11.037043  0.979177
## phosphoric.acid.flow                            -5.604078  0.310514
## trace.elements.flow                           -3.132603  0.362167
## ferrus.sulphate.flow                          -0.731192  0.271151
## magnesium.potassium.flow                     -1.010916  0.117298
## spare.dosing.pump.flow                       1.592732  0.105809
##
## t value Pr(>|t|)
## (Intercept)          -4.773 1.94e-06 ***
## vent.flow             13.093 < 2e-16 ***
## Station.3.Loop.Temperature -0.691 0.489791
## Station.5.Loop.Temperature  0.273 0.785039
## pH.at.stn1            20.178 < 2e-16 ***
## CH4.in.offgas..        4.563 5.32e-06 ***
## CO2.in.offgas..        3.439 0.000596 ***
## dissolved.oxygen.at.stn1 -2.179 0.029449 *
## dissolved.oxygen.at.stn5  8.012 1.84e-15 ***
## methane.flow.stn2      -2.123 0.033834 *
## methane.flow.stn3      12.378 < 2e-16 ***
## oxygen.flow.stn2        4.432 9.79e-06 ***
## oxygen.flow.stn4        11.254 < 2e-16 ***
## optical.density         -7.836 7.27e-15 ***
## ammonia.pump.flow.1     -18.414 < 2e-16 ***
## Tempered.Water.Temperature.before.Temped.water.cooler -7.663 2.73e-14 ***
## Cooling.Water.Return.for.Temped.System                -0.759 0.447699
## Cooling.loop.A.valve.opening..                      1.471 0.141552
## Cooling.loop.B.valve.opening..                      6.852 9.47e-12 ***
## Pressure.at.the.end.of.the.loop                    -3.259 0.001137 **
## oxygen.pressure.to.fermentor.loop.mixture          11.272 < 2e-16 ***
## phosphoric.acid.flow                            -18.048 < 2e-16 ***
## trace.elements.flow                           -8.650 < 2e-16 ***

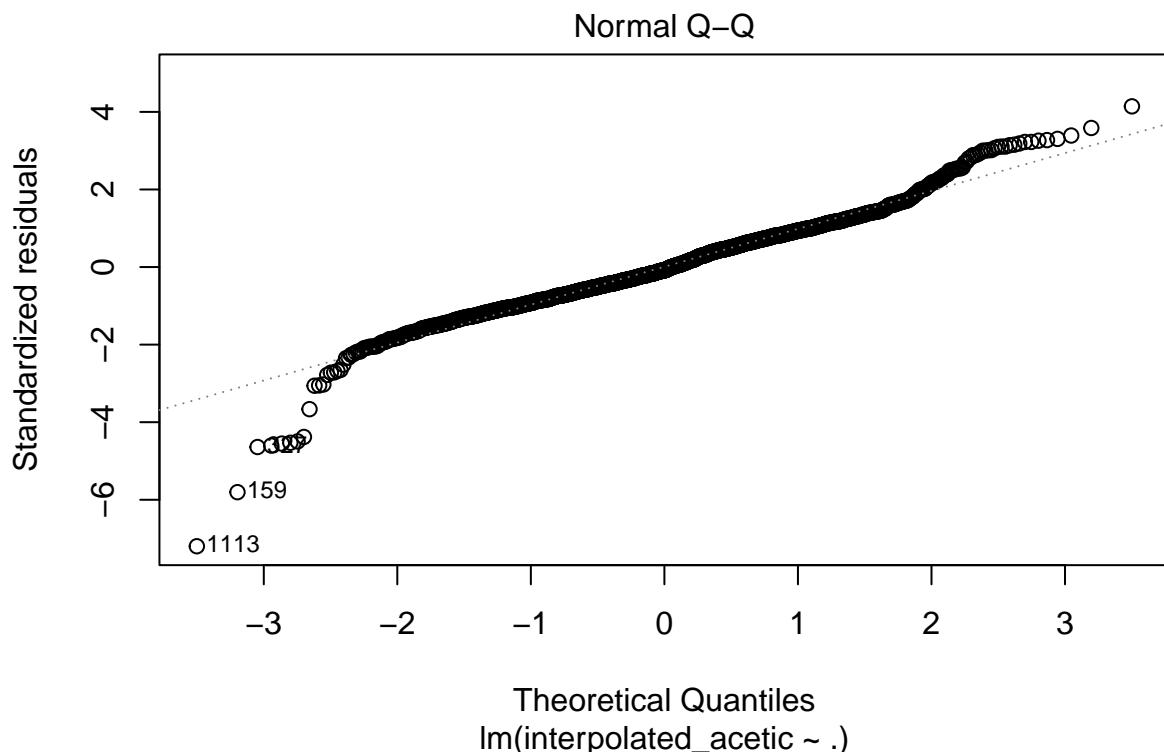
```

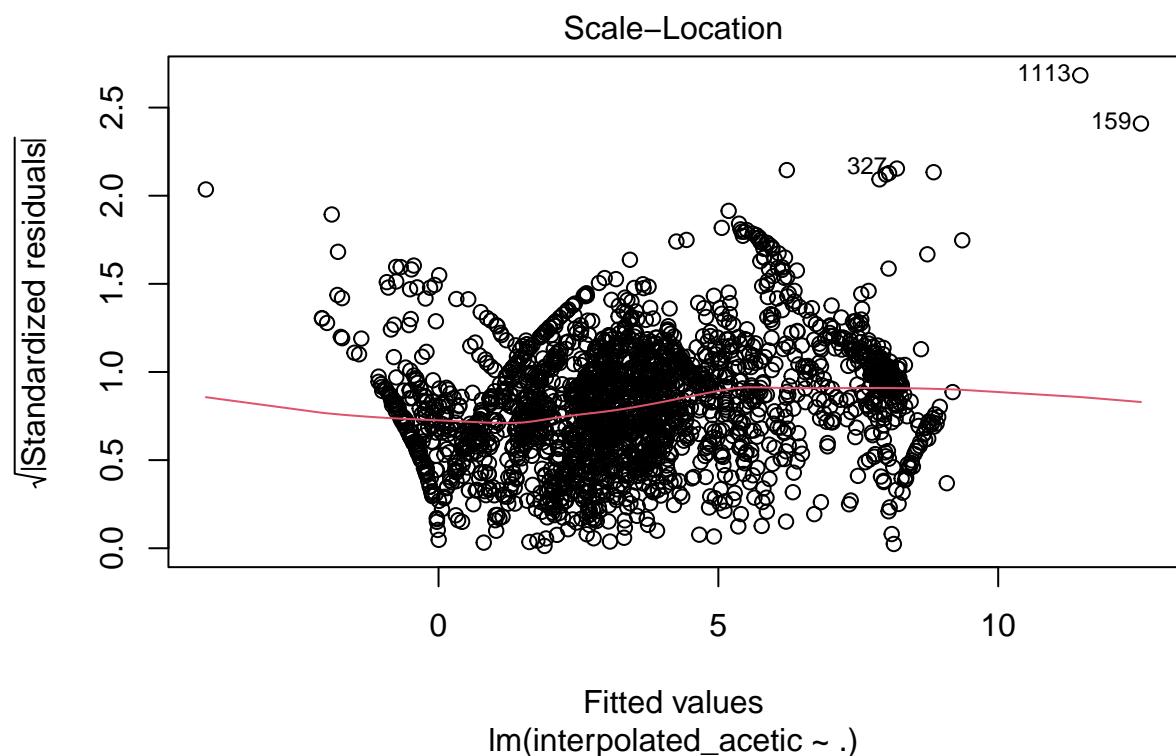
```

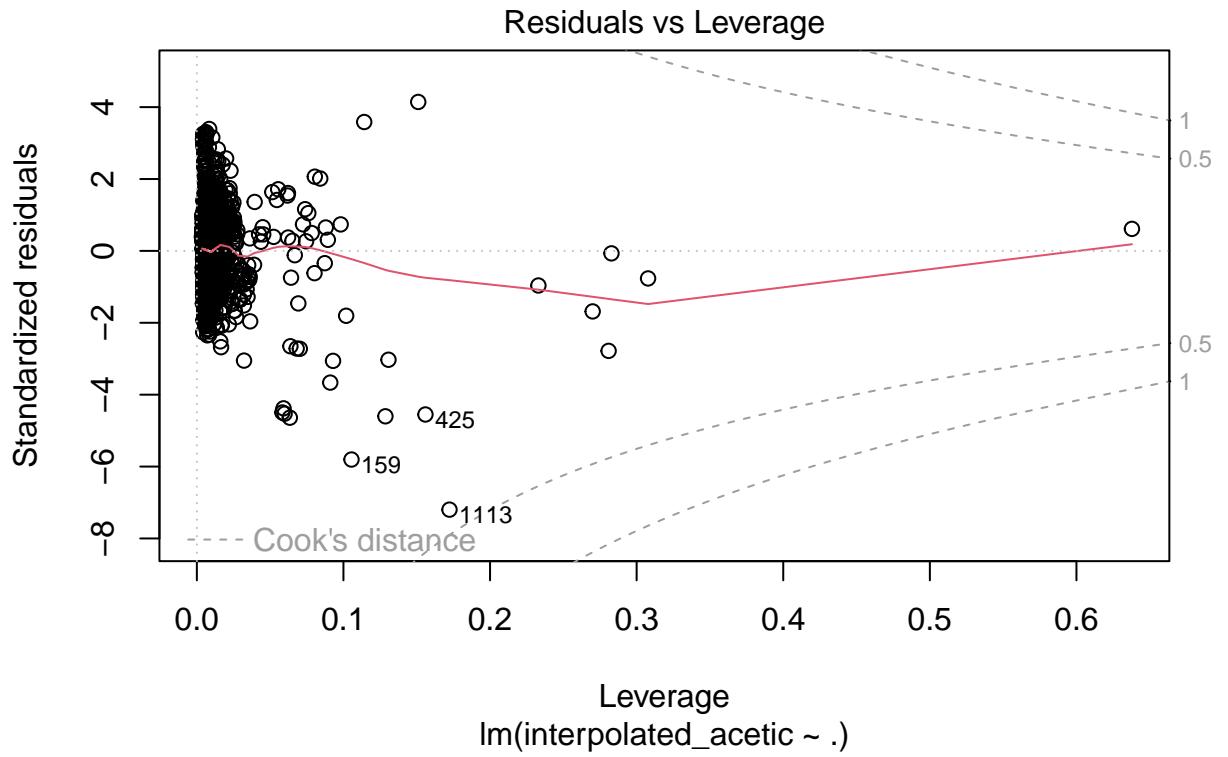
## ferrus.sulphate.flow           -2.697 0.007060 ***
## magnesium.potassium.flow      -8.618 < 2e-16 ***
## spare.dosing.pump.flow       15.053 < 2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.268 on 2133 degrees of freedom
## Multiple R-squared: 0.784, Adjusted R-squared: 0.7814
## F-statistic: 309.6 on 25 and 2133 DF, p-value: < 2.2e-16
CoefReg = coef(reg)
plot(reg)

```





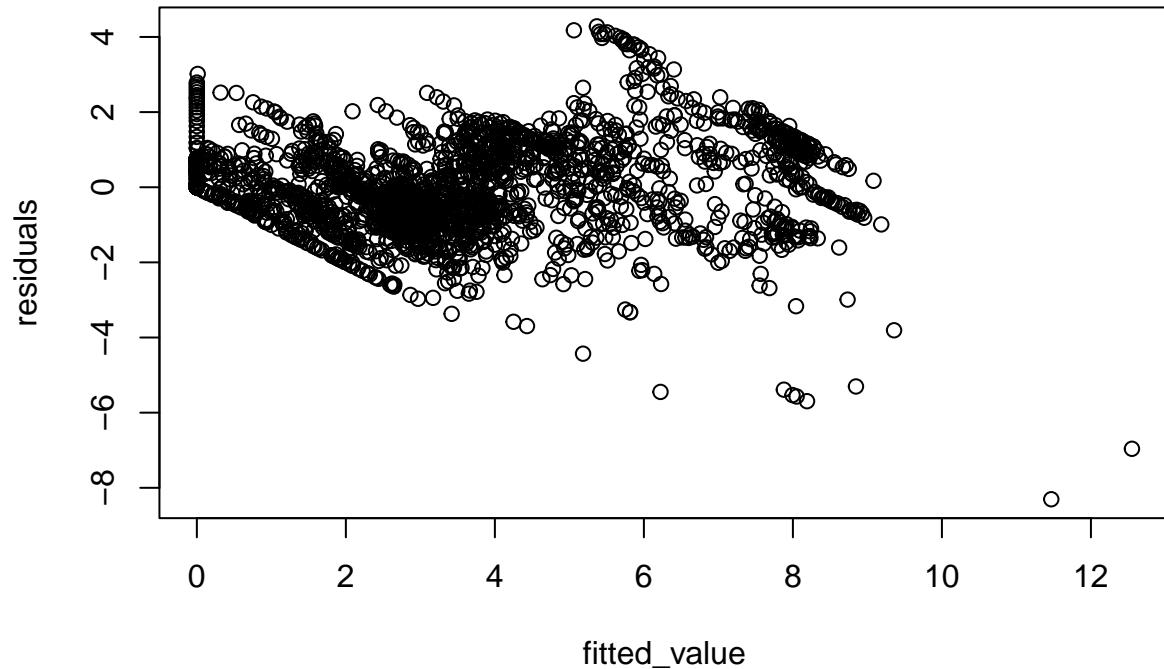




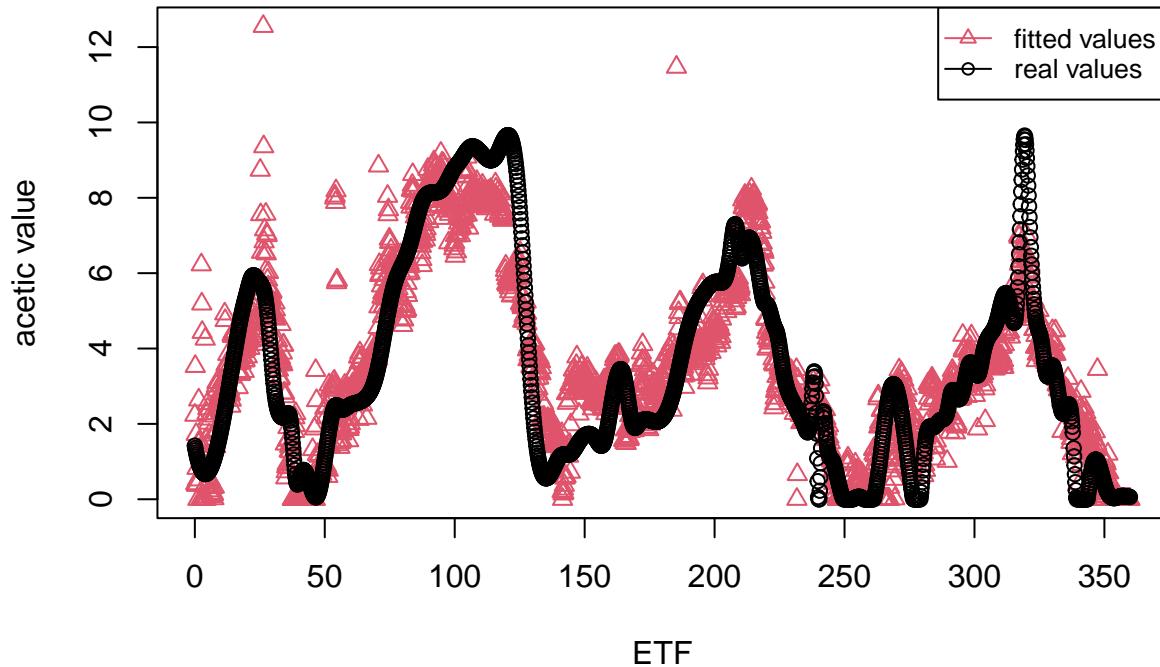
```
pred = predict(reg , data1[, c(index-1,68)])
pred[ which(pred<0) ] = 0
```

```
plot(pred, (data1[,68] - pred) , xlab = 'fitted_value' , ylab = 'residuals', main = 'residual plot with
```

residual plot with correction



```
plot(data1$EFT..Hours , pred , xlab='ETF' , ylab='acetic value' , col = 2 , pch = 2)
points(data1$EFT..Hours , data1$interpolated_acetic , main = 'with correction' , type='p' , col = 1 , p
legend("topright", cex = 0.8, c('fitted values',"real values"),lty=c(1, 1), pch=c(2, 1), col=c(2, 1))
```



```
Mean_Error_refit_lasso = mean( abs( pred - data1$interpolated_acetic) )
cat('mean absolute error of refitted-lasso: ', Mean_Error_lasso)
```

```
## mean absolute error of refitted-lasso: 1.140247
```

stepwise based on refitted-lasso

```
refit_lasso_step = step( reg )
```

```
## Start:  AIC=1051.64
## interpolated_acetic ~ vent.flow + Station.3.Loop.Temperature +
##   Station.5.Loop.Temperature + pH.at.stn1 + CH4.in.offgas.. +
##   CO2.in.offgas.. + dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn5 +
##   methane.flow.stn2 + methane.flow.stn3 + oxygen.flow.stn2 +
##   oxygen.flow.stn4 + optical.density + ammonia.pump.flow.1 +
##   Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
##   Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
##   Pressure.at.the.end.of.the.loop + oxygen..pressure.to.fermentor.loop.mixture +
##   phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
##   magnesium.potassium.flow + spare.dosing.pump.flow
##
##                                     Df Sum of Sq    RSS
## - Station.5.Loop.Temperature      1     0.12 3430.5
## - Station.3.Loop.Temperature      1     0.77 3431.1
## - Cooling.Water.Return.for.Temped.System  1     0.93 3431.3
## <none>                                3430.3
```

```

## - Cooling.loop.A.valve.opening..          1    3.48 3433.8
## - methane.flow.stn2                     1    7.25 3437.6
## - dissolved.oxygen.at.stn1             1    7.64 3438.0
## - ferrus.sulphate.flow                 1   11.69 3442.0
## - Pressure.at.the.end.of.the.loop      1   17.08 3447.4
## - CO2.in.offgas..                      1   19.02 3449.3
## - oxygen.flow.stn2                     1   31.60 3461.9
## - CH4.in.offgas..                      1   33.49 3463.8
## - Cooling.loop.B.valve.opening..        1   75.52 3505.8
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   94.45 3524.8
## - optical.density                     1   98.75 3529.1
## - dissolved.oxygen.at.stn5             1  103.24 3533.6
## - magnesium.potassium.flow            1  119.45 3549.8
## - trace.elements.flow                 1  120.32 3550.7
## - oxygen.flow.stn4                     1  203.68 3634.0
## - oxygen..pressure.to.fermentor.loop.mixture 1  204.33 3634.7
## - methane.flow.stn3                   1  246.41 3676.7
## - vent.flow                           1  275.68 3706.0
## - spare.dosing.pump.flow              1  364.41 3794.7
## - phosphoric.acid.flow                1  523.83 3954.2
## - ammonia.pump.flow.1                 1  545.33 3975.7
## - pH.at.stn1                          1  654.80 4085.1
##
##                                         AIC
## - Station.5.Loop.Temperature          1049.7
## - Station.3.Loop.Temperature          1050.1
## - Cooling.Water.Return.for.Temped.System 1050.2
## <none>                                1051.6
## - Cooling.loop.A.valve.opening..      1051.8
## - methane.flow.stn2                  1054.2
## - dissolved.oxygen.at.stn1           1054.4
## - ferrus.sulphate.flow               1057.0
## - Pressure.at.the.end.of.the.loop    1060.4
## - CO2.in.offgas..                    1061.6
## - oxygen.flow.stn2                  1069.4
## - CH4.in.offgas..                    1070.6
## - Cooling.loop.B.valve.opening..     1096.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1108.3
## - optical.density                   1110.9
## - dissolved.oxygen.at.stn5           1113.7
## - magnesium.potassium.flow          1123.5
## - trace.elements.flow                1124.1
## - oxygen.flow.stn4                  1174.2
## - oxygen..pressure.to.fermentor.loop.mixture 1174.6
## - methane.flow.stn3                  1199.4
## - vent.flow                         1216.5
## - spare.dosing.pump.flow            1267.6
## - phosphoric.acid.flow              1356.5
## - ammonia.pump.flow.1               1368.2
## - pH.at.stn1                        1426.8
##
## Step: AIC=1049.72
## interpolated_acetic ~ vent.flow + Station.3.Loop.Temperature +
##      pH.at.stn1 + CH4.in.offgas.. + CO2.in.offgas.. + dissolved.oxygen.at.stn1 +
##      dissolved.oxygen.at.stn5 + methane.flow.stn2 + methane.flow.stn3 +

```

```

##      oxygen.flow.stn2 + oxygen.flow.stn4 + optical.density + ammonia.pump.flow.1 +
##      Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
##      Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
##      Pressure.at.the.end.of.the.loop + oxygen..pressure.to.fermentor.loop.mixture +
##      phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
##      magnesium.potassium.flow + spare.dosing.pump.flow
##
##                                     Df Sum of Sq   RSS
## - Cooling.Water.Return.for.Temped.System           1    0.87 3431.3
## - Station.3.Loop.Temperature                      1    0.99 3431.4
## <none>                                         3430.5
## - Cooling.loop.A.valve.opening..                 1    3.49 3433.9
## - methane.flow.stn2                            1    7.38 3437.8
## - dissolved.oxygen.at.stn1                     1    7.65 3438.1
## - ferrus.sulphate.flow                         1   11.63 3442.1
## - Pressure.at.the.end.of.the.loop              1   17.15 3447.6
## - CO2.in.offgas..                            1   19.14 3449.6
## - oxygen.flow.stn2                           1   31.88 3462.3
## - CH4.in.offgas..                           1   33.54 3464.0
## - Cooling.loop.B.valve.opening..               1   75.49 3505.9
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   98.58 3529.0
## - optical.density                           1   98.87 3529.3
## - dissolved.oxygen.at.stn5                  1  103.22 3533.7
## - magnesium.potassium.flow                 1  119.66 3550.1
## - trace.elements.flow                       1  120.79 3551.2
## - oxygen..pressure.to.fermentor.loop.mixture 1  204.37 3634.8
## - oxygen.flow.stn4                          1  206.79 3637.2
## - methane.flow.stn3                         1  248.51 3679.0
## - vent.flow                                1  275.72 3706.2
## - spare.dosing.pump.flow                  1  366.69 3797.1
## - phosphoric.acid.flow                   1  525.75 3956.2
## - ammonia.pump.flow.1                    1  545.21 3975.7
## - pH.at.stn1                               1  656.76 4087.2
##
##                                     AIC
## - Cooling.Water.Return.for.Temped.System        1048.3
## - Station.3.Loop.Temperature                   1048.3
## <none>                                         1049.7
## - Cooling.loop.A.valve.opening..               1049.9
## - methane.flow.stn2                           1052.4
## - dissolved.oxygen.at.stn1                  1052.5
## - ferrus.sulphate.flow                        1055.0
## - Pressure.at.the.end.of.the.loop            1058.5
## - CO2.in.offgas..                           1059.7
## - oxygen.flow.stn2                           1067.7
## - CH4.in.offgas..                           1068.7
## - Cooling.loop.B.valve.opening..             1094.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1108.9
## - optical.density                           1109.1
## - dissolved.oxygen.at.stn5                  1111.7
## - magnesium.potassium.flow                 1121.8
## - trace.elements.flow                       1122.4
## - oxygen..pressure.to.fermentor.loop.mixture 1172.7
## - oxygen.flow.stn4                           1174.1
## - methane.flow.stn3                         1198.7

```

```

## - vent.flow 1214.6
## - spare.dosing.pump.flow 1267.0
## - phosphoric.acid.flow 1355.6
## - ammonia.pump.flow.1 1366.2
## - pH.at.stn1 1425.9
##
## Step: AIC=1048.27
## interpolated_acetic ~ vent.flow + Station.3.Loop.Temperature +
## pH.at.stn1 + CH4.in.offgas.. + CO2.in.offgas.. + dissolved.oxygen.at.stn1 +
## dissolved.oxygen.at.stn5 + methane.flow.stn2 + methane.flow.stn3 +
## oxygen.flow.stn2 + oxygen.flow.stn4 + optical.density + ammonia.pump.flow.1 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + phosphoric.acid.flow +
## trace.elements.flow + ferrus.sulphate.flow + magnesium.potassium.flow +
## spare.dosing.pump.flow
##
## Df Sum of Sq RSS
## - Station.3.Loop.Temperature 1 1.69 3433.0
## - Cooling.loop.A.valve.opening.. 1 2.93 3434.3
## <none> 3431.3
## - methane.flow.stn2 1 7.22 3438.5
## - dissolved.oxygen.at.stn1 1 7.48 3438.8
## - ferrus.sulphate.flow 1 11.60 3442.9
## - Pressure.at.the.end.of.the.loop 1 17.30 3448.6
## - CO2.in.offgas.. 1 18.79 3450.1
## - oxygen.flow.stn2 1 31.22 3462.5
## - CH4.in.offgas.. 1 36.44 3467.8
## - Cooling.loop.B.valve.opening.. 1 75.65 3507.0
## - optical.density 1 98.77 3530.1
## - dissolved.oxygen.at.stn5 1 103.88 3535.2
## - Tempered.Water.Temperature.before.Temped.water.cooler 1 110.48 3541.8
## - magnesium.potassium.flow 1 119.41 3550.7
## - trace.elements.flow 1 119.92 3551.2
## - oxygen..pressure.to.fermentor.loop.mixture 1 212.04 3643.4
## - oxygen.flow.stn4 1 212.18 3643.5
## - methane.flow.stn3 1 252.65 3684.0
## - vent.flow 1 276.03 3707.4
## - spare.dosing.pump.flow 1 366.47 3797.8
## - phosphoric.acid.flow 1 528.00 3959.3
## - ammonia.pump.flow.1 1 552.23 3983.6
## - pH.at.stn1 1 712.56 4143.9
##
## AIC
## - Station.3.Loop.Temperature 1047.3
## - Cooling.loop.A.valve.opening.. 1048.1
## <none> 1048.3
## - methane.flow.stn2 1050.8
## - dissolved.oxygen.at.stn1 1051.0
## - ferrus.sulphate.flow 1053.6
## - Pressure.at.the.end.of.the.loop 1057.1
## - CO2.in.offgas.. 1058.1
## - oxygen.flow.stn2 1065.8
## - CH4.in.offgas.. 1069.1
## - Cooling.loop.B.valve.opening.. 1093.3

```

```

## - optical.density 1107.5
## - dissolved.oxygen.at.stn5 1110.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1114.7
## - magnesium.potassium.flow 1120.1
## - trace.elements.flow 1120.4
## - oxygen..pressure.to.fermentor.loop.mixture 1175.7
## - oxygen.flow.stn4 1175.8
## - methane.flow.stn3 1199.7
## - vent.flow 1213.3
## - spare.dosing.pump.flow 1265.3
## - phosphoric.acid.flow 1355.3
## - ammonia.pump.flow.1 1368.5
## - pH.at.stn1 1453.6
##
## Step: AIC=1047.33
## interpolated_acetic ~ vent.flow + pH.at.stn1 + CH4.in.offgas.. +
## CO2.in.offgas.. + dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn5 +
## methane.flow.stn2 + methane.flow.stn3 + oxygen.flow.stn2 +
## oxygen.flow.stn4 + optical.density + ammonia.pump.flow.1 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + phosphoric.acid.flow +
## trace.elements.flow + ferrus.sulphate.flow + magnesium.potassium.flow +
## spare.dosing.pump.flow
##
##                                     Df Sum of Sq    RSS
## - Cooling.loop.A.valve.opening.. 1   2.63 3435.6
## <none>                           3433.0
## - methane.flow.stn2            1   7.11 3440.1
## - dissolved.oxygen.at.stn1     1   8.27 3441.3
## - ferrus.sulphate.flow        1   13.44 3446.5
## - Pressure.at.the.end.of.the.loop 1   17.31 3450.3
## - CO2.in.offgas..              1   17.40 3450.4
## - oxygen.flow.stn2             1   30.87 3463.9
## - CH4.in.offgas..              1   36.44 3469.5
## - Cooling.loop.B.valve.opening.. 1   74.50 3507.5
## - optical.density              1   98.96 3532.0
## - dissolved.oxygen.at.stn5     1   105.61 3538.6
## - trace.elements.flow          1   118.69 3551.7
## - magnesium.potassium.flow    1   120.26 3553.3
## - oxygen.flow.stn4             1   217.64 3650.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   219.77 3652.8
## - oxygen..pressure.to.fermentor.loop.mixture 1   220.43 3653.5
## - methane.flow.stn3            1   252.06 3685.1
## - vent.flow                    1   276.87 3709.9
## - spare.dosing.pump.flow      1   364.81 3797.8
## - phosphoric.acid.flow        1   529.90 3962.9
## - ammonia.pump.flow.1         1   581.48 4014.5
## - pH.at.stn1                  1   717.21 4150.2
##
##                                     AIC
## - Cooling.loop.A.valve.opening.. 1047.0
## <none>                           1047.3
## - methane.flow.stn2            1049.8
## - dissolved.oxygen.at.stn1     1050.5

```

```

## - ferrus.sulphate.flow 1053.8
## - Pressure.at.the.end.of.the.loop 1056.2
## - CO2.in.offgas.. 1056.2
## - oxygen.flow.stn2 1064.7
## - CH4.in.offgas.. 1068.1
## - Cooling.loop.B.valve.opening.. 1091.7
## - optical.density 1106.7
## - dissolved.oxygen.at.stn5 1110.8
## - trace.elements.flow 1118.7
## - magnesium.potassium.flow 1119.7
## - oxygen.flow.stn4 1178.0
## - Tempered.Water.Temperature.before.Temped.water.cooler 1179.3
## - oxygen..pressure.to.fermentor.loop.mixture 1179.7
## - methane.flow.stn3 1198.3
## - vent.flow 1212.8
## - spare.dosing.pump.flow 1263.4
## - phosphoric.acid.flow 1355.2
## - ammonia.pump.flow.1 1383.2
## - pH.at.stn1 1454.9
##
## Step: AIC=1046.98
## interpolated_acetic ~ vent.flow + pH.at.stn1 + CH4.in.offgas.. +
## CO2.in.offgas.. + dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn5 +
## methane.flow.stn2 + methane.flow.stn3 + oxygen.flow.stn2 +
## oxygen.flow.stn4 + optical.density + ammonia.pump.flow.1 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.loop.B.valve.opening.. +
## Pressure.at.the.end.of.the.loop + oxygen..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow
##
##                                     Df Sum of Sq    RSS
## <none>                               3435.6
## - methane.flow.stn2 1      7.22 3442.9
## - dissolved.oxygen.at.stn1 1      9.39 3445.0
## - ferrus.sulphate.flow 1     13.71 3449.4
## - Pressure.at.the.end.of.the.loop 1     16.75 3452.4
## - CO2.in.offgas.. 1     17.68 3453.3
## - oxygen.flow.stn2 1     31.61 3467.3
## - CH4.in.offgas.. 1     36.38 3472.0
## - optical.density 1     97.37 3533.0
## - dissolved.oxygen.at.stn5 1    104.42 3540.1
## - trace.elements.flow 1    121.58 3557.2
## - magnesium.potassium.flow 1    126.24 3561.9
## - oxygen.flow.stn4 1    216.10 3651.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1    218.08 3653.7
## - oxygen..pressure.to.fermentor.loop.mixture 1    219.41 3655.1
## - Cooling.loop.B.valve.opening.. 1    224.16 3659.8
## - methane.flow.stn3 1    269.21 3704.9
## - vent.flow 1    274.28 3709.9
## - spare.dosing.pump.flow 1    381.63 3817.3
## - phosphoric.acid.flow 1    577.00 4012.6
## - ammonia.pump.flow.1 1    579.01 4014.7
## - pH.at.stn1 1    755.46 4191.1
##
AIC

```

```

## <none>                                1047.0
## - methane.flow.stn2                  1049.5
## - dissolved.oxygen.at.stn1          1050.9
## - ferrus.sulphate.flow              1053.6
## - Pressure.at.the.end.of.the.loop   1055.5
## - CO2.in.offgas..                   1056.1
## - oxygen.flow.stn2                 1064.8
## - CH4.in.offgas..                   1067.7
## - optical.density                  1105.3
## - dissolved.oxygen.at.stn5          1109.6
## - trace.elements.flow              1120.1
## - magnesium.potassium.flow         1122.9
## - oxygen.flow.stn4                 1176.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1177.9
## - oxygen..pressure.to.fermentor.loop.mixture    1178.6
## - Cooling.loop.B.valve.opening..      1181.4
## - methane.flow.stn3                1207.9
## - vent.flow                         1210.8
## - spare.dosing.pump.flow           1272.4
## - phosphoric.acid.flow             1380.2
## - ammonia.pump.flow.1              1381.2
## - pH.at.stn1                        1474.1

cat('before stepwise selection, R-squared for refitted lasso is: ', summary(reg)$r.squared)

## before stepwise selection, R-squared for refitted lasso is:  0.7839793
cat('after stepwise selection, R-squared for refitted lasso is: ', summary(refit_lasso_step)$r.squared)

## after stepwise selection, R-squared for refitted lasso is:  0.7836448

```

Lm stepwise

```

lmstep = step( lm(interpolated_acetic~, data = data1)  )

## Start:  AIC=-769.87
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## pH.at.stn1 + CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. +
## LEL.in.offgas.. + dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + NH3.online.reading + optical.density +
## ammonia.pump.flow.1 + ammonia.pump.flow.2 + Cooling.Loop.A.Broth.Return.to.Fermenter.mixer +
## Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 + Tempered.Water.Temperature.before.Temped.
## Tempered.Water.Temperature.after.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + headspace.pressure +
## Pressure.at.the.end.of.the.loop + oxygen..pressure.to.fermentor.loop.mixture +
## methane..pressure.to.fermentor.loop.mixture + partial.pressure..DP. +
## phosphoric.acid.flow + sodium.hydroxide.flow + trace.elements.flow +
## ferrus.sulphate.flow + calcium.chloride.flow + magnesium.potassium.flow +

```

```

## spare.dosing.pump.flow + phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
## ammonia.totaliser + Methane.totaliser + oxygen.totaliser +
## Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##
## Step: AIC=-769.87
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## pH.at.stn1 + CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. +
## LEL.in.offgas.. + dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + NH3.online.reading + optical.density +
## ammonia.pump.flow.1 + ammonia.pump.flow.2 + Cooling.Loop.A.Broth.Return.to.Fermenter.mixer +
## Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 + Tempered.Water.Temperature.before.Temped.Water.Temperature.after.Temped.Water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totaliser +
## spare.dosing.pump.totaliser + ammonia.totaliser + Methane.totaliser +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
## - NH3.online.reading
## - LEL.in.offgas..
## - dissolved.oxygen.at.stn1
## - pH.at.stn1
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer
## - CO2.in.offgas..
## - sodium.hydroxide.flow
## - partial.pressure..DP.
## - Pressure.at.the.end.of.the.loop
## - Tempered.Water.Temperature.before.Temped.Water.cooler
## - Tempered.Water.Temperature.after.Temped.Water.cooler
## - Cooling.loop.A.valve.opening..
## - ammonia.pump.flow.1
## - methane..pressure.to.fermentor.loop.mixture
## - Fermentor.fliud.to.ammonia...OD.meter.L.h
## - pump.inlet
## - Station.3.Loop.Temperature
## - total.air.flow
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117
## - CH4.in.offgas..
## <none>

```

	Df	Sum of Sq	RSS
## - NH3.online.reading	1	0.00	1420.5
## - LEL.in.offgas..	1	0.00	1420.5
## - dissolved.oxygen.at.stn1	1	0.01	1420.5
## - pH.at.stn1	1	0.01	1420.5
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer	1	0.07	1420.5
## - CO2.in.offgas..	1	0.16	1420.6
## - sodium.hydroxide.flow	1	0.18	1420.7
## - partial.pressure..DP.	1	0.21	1420.7
## - Pressure.at.the.end.of.the.loop	1	0.24	1420.7
## - Tempered.Water.Temperature.before.Temped.Water.cooler	1	0.33	1420.8
## - Tempered.Water.Temperature.after.Temped.Water.cooler	1	0.33	1420.8
## - Cooling.loop.A.valve.opening..	1	0.40	1420.9
## - ammonia.pump.flow.1	1	0.47	1420.9
## - methane..pressure.to.fermentor.loop.mixture	1	0.49	1421.0
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	1	0.68	1421.2
## - pump.inlet	1	0.70	1421.2
## - Station.3.Loop.Temperature	1	0.71	1421.2
## - total.air.flow	1	0.87	1421.3
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	1	0.98	1421.5
## - CH4.in.offgas..	1	1.30	1421.8
## <none>			1420.5

## - oxygen.flow.stn5	1	1.33	1421.8
## - dissolved.oxygen.at.stn2	1	1.44	1421.9
## - oxygen.totaliser	1	1.83	1422.3
## - Level.on.the.seperator	1	1.86	1422.3
## - pressure.at.position.4	1	1.95	1422.4
## - oxygen.flow.stn3	1	2.09	1422.6
## - Station.5.Loop.Temperature	1	2.51	1423.0
## - pump.outlet	1	2.65	1423.1
## - oxygen.flow.stn1	1	3.12	1423.6
## - vessel	1	3.62	1424.1
## - pH.at.stn3	1	3.93	1424.4
## - calcium.chloride.totaliser	1	4.43	1424.9
## - O2.in.offgas..	1	5.33	1425.8
## - Cooling.Water.Return.for.Temped.System	1	5.99	1426.5
## - oxygen.flow.stn4	1	6.16	1426.6
## - Methane.totalier	1	6.38	1426.9
## - methane.flow.stn5	1	6.41	1426.9
## - ammonia.totalier	1	6.74	1427.2
## - pH.at.stn5	1	7.46	1427.9
## - methane.flow.stn2	1	8.72	1429.2
## - vent.flow	1	8.81	1429.3
## - oxygen.flow.stn2	1	9.72	1430.2
## - trace.elements.totaliser	1	9.89	1430.4
## - harvest.flow	1	10.17	1430.7
## - EFT..Hours	1	10.81	1431.3
## - ammonia.pump.flow.2	1	13.04	1433.5
## - spare.dosing.pump.flow	1	14.34	1434.8
## - calcium.chloride.flow	1	15.60	1436.1
## - dissolved.oxygen.at.stn5	1	15.80	1436.3
## - methane.flow.stn4	1	17.38	1437.9
## - ferrous.sulphate.totaliser	1	18.00	1438.5
## - methane.flow.stn3	1	19.36	1439.8
## - methane.flow.stn1	1	20.85	1441.3
## - ferrus.sulphate.flow	1	25.34	1445.8
## - oxygen..pressure.to.fermentor.loop.mixture	1	25.70	1446.2
## - magnesium.potassium.totalier	1	28.69	1449.2
## - Cooling.loop.B.valve.opening..	1	32.70	1453.2
## - optical.density	1	53.07	1473.5
## - magnesium.potassium.flow	1	53.71	1474.2
## - phosphoric.acid.flow	1	63.46	1483.9
## - dissolved.oxygen.at.stn3	1	89.25	1509.7
## - phosphoric.acid.totaliser	1	90.12	1510.6
## - trace.elements.flow	1	147.82	1568.3
## - dissolved.oxygen.at.stn4	1	190.66	1611.1
## - spare.dosing.pump.totaliser	1	205.65	1626.1
## - sodium.hydroxide.totaliser	1	745.08	2165.6
##		AIC	
## - NH3.online.reading	-771.87		
## - LEL.in.offgas..	-771.87		
## - dissolved.oxygen.at.stn1	-771.86		
## - pH.at.stn1	-771.86		
## - CoolingLoop.A.Broth.Return.to.Fermenter.mixer	-771.77		
## - CO2.in.offgas..	-771.64		
## - sodium.hydroxide.flow	-771.60		

## - partial.pressure..DP.	-771.56
## - Pressure.at.the.end.of.the.loop	-771.50
## - Tempered.Water.Temperature.before.Temped.water.cooler	-771.38
## - Tempered.Water.Temperature.after.Temped.water.cooler	-771.37
## - Cooling.loop.A.valve.opening..	-771.26
## - ammonia.pump.flow.1	-771.16
## - methane..pressure.to.fermentor.loop.mixture	-771.13
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-770.84
## - pump.inlet	-770.81
## - Station.3.Loop.Temperature	-770.79
## - total.air.flow	-770.55
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-770.38
## - CH4.in.offgas..	-769.90
## <none>	-769.87
## - oxygen.flow.stn5	-769.85
## - dissolved.oxygen.at.stn2	-769.69
## - oxygen.totaliser	-769.10
## - Level.on.the.seperator	-769.05
## - pressure.at.position.4	-768.91
## - oxygen.flow.stn3	-768.70
## - Station.5.Loop.Temperature	-768.06
## - pump.outlet	-767.85
## - oxygen.flow.stn1	-767.13
## - vessel	-766.38
## - pH.at.stn3	-765.90
## - calcium.chloride.totaliser	-765.16
## - O2.in.offgas..	-763.80
## - Cooling.Water.Return.for.Temped.System	-762.79
## - oxygen.flow.stn4	-762.53
## - Methane.totalier	-762.20
## - methane.flow.stn5	-762.16
## - ammonia.totalier	-761.65
## - pH.at.stn5	-760.57
## - methane.flow.stn2	-758.66
## - vent.flow	-758.52
## - oxygen.flow.stn2	-757.14
## - trace.elements.totaliser	-756.90
## - harvest.flow	-756.46
## - EFT..Hours	-755.50
## - ammonia.pump.flow.2	-752.15
## - spare.dosing.pump.flow	-750.18
## - calcium.chloride.flow	-748.29
## - dissolved.oxygen.at.stn5	-747.99
## - methane.flow.stn4	-745.61
## - ferrous.sulphate.totaliser	-744.69
## - methane.flow.stn3	-742.65
## - methane.flow.stn1	-740.42
## - ferrus.sulphate.flow	-733.70
## - oxygen..pressure.to.fermentor.loop.mixture	-733.16
## - magnesium.potassium.totalier	-728.70
## - Cooling.loop.B.valve.opening..	-722.73
## - optical.density	-692.69
## - magnesium.potassium.flow	-691.74
## - phosphoric.acid.flow	-677.52

```

## - dissolved.oxygen.at.stn3           -640.31
## - phosphoric.acid.totaliser        -639.07
## - trace.elements.flow              -558.14
## - dissolved.oxygen.at.stn4           -499.95
## - spare.dosing.pump.totaliser      -479.96
## - sodium.hydroxide.totaliser       138.54
##
## Step: AIC=-771.87
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## pH.at.stn1 + CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. +
## LEL.in.offgas.. + dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + Cooling.Loop.A.Broth.Return.to.Fermenter.mixer +
## Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 + Tempered.Water.Temperature.before.Temped.Water.Temperature.after.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totaliser +
## spare.dosing.pump.totaliser + ammonia.totalier + Methane.totalier +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq   RSS
## - LEL.in.offgas..                  1  0.00 1420.5
## - dissolved.oxygen.at.stn1        1  0.01 1420.5
## - pH.at.stn1                      1  0.01 1420.5
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer    1  0.07 1420.5
## - CO2.in.offgas..                  1  0.16 1420.6
## - sodium.hydroxide.flow            1  0.18 1420.7
## - partial.pressure..DP.             1  0.21 1420.7
## - Pressure.at.the.end.of.the.loop 1  0.24 1420.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1  0.33 1420.8
## - Tempered.Water.Temperature.after.Temped.water.cooler 1  0.33 1420.8
## - Cooling.loop.A.valve.opening..   1  0.40 1420.9
## - ammonia.pump.flow.1              1  0.48 1421.0
## - methane..pressure.to.fermentor.loop.mixture          1  0.49 1421.0
## - Fermentor.fliud.to.ammonia...OD.meter.L.h            1  0.68 1421.2
## - pump.inlet                         1  0.70 1421.2
## - Station.3.Loop.Temperature         1  0.71 1421.2
## - total.air.flow                     1  0.87 1421.3
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 1  0.99 1421.5
## - CH4.in.offgas..                    1  1.30 1421.8
## <none>                                1420.5
## - oxygen.flow.stn5                  1  1.34 1421.8

```

## - dissolved.oxygen.at.stn2	1	1.44	1421.9
## - oxygen.totaliser	1	1.84	1422.3
## - Level.on.the.seperator	1	1.86	1422.3
## - pressure.at.position.4	1	1.95	1422.4
## - oxygen.flow.stn3	1	2.13	1422.6
## - Station.5.Loop.Temperature	1	2.51	1423.0
## - pump.outlet	1	2.66	1423.1
## - oxygen.flow.stn1	1	3.13	1423.6
## - vessel	1	3.62	1424.1
## - pH.at.stn3	1	3.95	1424.4
## - calcium.chloride.totaliser	1	4.44	1424.9
## - O2.in.offgas..	1	5.33	1425.8
## - Cooling.Water.Return.for.Temped.System	1	6.01	1426.5
## - oxygen.flow.stn4	1	6.29	1426.8
## - Methane.totalier	1	6.38	1426.9
## - methane.flow.stn5	1	6.46	1426.9
## - ammonia.totalier	1	6.87	1427.3
## - pH.at.stn5	1	7.64	1428.1
## - methane.flow.stn2	1	8.74	1429.2
## - vent.flow	1	8.83	1429.3
## - oxygen.flow.stn2	1	9.72	1430.2
## - trace.elements.totaliser	1	9.95	1430.4
## - harvest.flow	1	10.20	1430.7
## - EFT..Hours	1	10.82	1431.3
## - ammonia.pump.flow.2	1	13.27	1433.7
## - spare.dosing.pump.flow	1	14.34	1434.8
## - calcium.chloride.flow	1	15.60	1436.1
## - dissolved.oxygen.at.stn5	1	15.83	1436.3
## - methane.flow.stn4	1	17.70	1438.2
## - ferrous.sulphate.totaliser	1	18.21	1438.7
## - methane.flow.stn3	1	19.46	1439.9
## - methane.flow.stn1	1	21.01	1441.5
## - ferrus.sulphate.flow	1	25.39	1445.9
## - oxygen..pressure.to.fermentor.loop.mixture	1	25.76	1446.2
## - magnesium.potassium.totalier	1	31.32	1451.8
## - Cooling.loop.B.valve.opening..	1	32.70	1453.2
## - magnesium.potassium.flow	1	54.56	1475.0
## - optical.density	1	54.81	1475.3
## - phosphoric.acid.flow	1	63.56	1484.0
## - phosphoric.acid.totaliser	1	90.49	1511.0
## - dissolved.oxygen.at.stn3	1	92.02	1512.5
## - trace.elements.flow	1	149.33	1569.8
## - dissolved.oxygen.at.stn4	1	190.66	1611.1
## - spare.dosing.pump.totaliser	1	217.58	1638.0
## - sodium.hydroxide.totaliser	1	784.20	2204.7
##		AIC	
## - LEL.in.offgas..	-773.87		
## - dissolved.oxygen.at.stn1	-773.86		
## - pH.at.stn1	-773.86		
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer	-773.77		
## - CO2.in.offgas..	-773.64		
## - sodium.hydroxide.flow	-773.60		
## - partial.pressure..DP.	-773.56		
## - Pressure.at.the.end.of.the.loop	-773.50		

```

## - Tempered.Water.Temperature.before.Temped.water.cooler -773.38
## - Tempered.Water.Temperature.after.Temped.water.cooler -773.37
## - Cooling.loop.A.valve.opening.. -773.26
## - ammonia.pump.flow.1 -773.15
## - methane..pressure.to.fermentor.loop.mixture -773.13
## - Fermentor.fliud.to.ammonia...OD.meter.L.h -772.84
## - pump.inlet -772.81
## - Station.3.Loop.Temperature -772.79
## - total.air.flow -772.55
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 -772.37
## - CH4.in.offgas.. -771.90
## <none> -771.87
## - oxygen.flow.stn5 -771.84
## - dissolved.oxygen.at.stn2 -771.69
## - oxygen.totaliser -771.09
## - Level.on.the.seperator -771.05
## - pressure.at.position.4 -770.91
## - oxygen.flow.stn3 -770.64
## - Station.5.Loop.Temperature -770.06
## - pump.outlet -769.84
## - oxygen.flow.stn1 -769.13
## - vessel -768.38
## - pH.at.stn3 -767.88
## - calcium.chloride.totaliser -767.13
## - O2.in.offgas.. -765.79
## - Cooling.Water.Return.for.Temped.System -764.76
## - oxygen.flow.stn4 -764.33
## - Methane.totalier -764.19
## - methane.flow.stn5 -764.07
## - ammonia.totalier -763.46
## - pH.at.stn5 -762.29
## - methane.flow.stn2 -760.62
## - vent.flow -760.49
## - oxygen.flow.stn2 -759.14
## - trace.elements.totaliser -758.80
## - harvest.flow -758.43
## - EFT..Hours -757.48
## - ammonia.pump.flow.2 -753.80
## - spare.dosing.pump.flow -752.18
## - calcium.chloride.flow -750.29
## - dissolved.oxygen.at.stn5 -749.94
## - methane.flow.stn4 -747.14
## - ferrous.sulphate.totaliser -746.38
## - methane.flow.stn3 -744.50
## - methane.flow.stn1 -742.18
## - ferrus.sulphate.flow -735.63
## - oxygen..pressure.to.fermentor.loop.mixture -735.08
## - magnesium.potassium.totalier -726.79
## - Cooling.loop.B.valve.opening.. -724.73
## - magnesium.potassium.flow -692.50
## - optical.density -692.13
## - phosphoric.acid.flow -679.37
## - phosphoric.acid.totaliser -640.54
## - dissolved.oxygen.at.stn3 -638.35

```

```

## - trace.elements.flow -558.07
## - dissolved.oxygen.at.stn4 -501.95
## - spare.dosing.pump.totaliser -466.18
## - sodium.hydroxide.totaliser 175.20
##
## Step: AIC=-773.87
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## pH.at.stn1 + CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. +
## dissolved.oxygen.at.stn1 + dissolved.oxygen.at.stn2 + dissolved.oxygen.at.stn3 +
## dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 + methane.flow.stn1 +
## methane.flow.stn2 + methane.flow.stn3 + methane.flow.stn4 +
## methane.flow.stn5 + oxygen.flow.stn1 + oxygen.flow.stn2 +
## oxygen.flow.stn3 + oxygen.flow.stn4 + oxygen.flow.stn5 +
## optical.density + ammonia.pump.flow.1 + ammonia.pump.flow.2 +
## Cooling.Loop.A.Broth.Return.to.Fermenter.mixer + Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.
## Tempered.Water.Temperature.before.Temped.water.cooler + Tempered.Water.Temperature.after.Temped.
## Cooling.Water.Return.for.Temped.System + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totaliser +
## spare.dosing.pump.totaliser + ammonia.totaliser + Methane.totaliser +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - pH.at.stn1                      1   0.01 1420.5
## - dissolved.oxygen.at.stn1        1   0.01 1420.5
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer      1   0.07 1420.5
## - CO2.in.offgas..                  1   0.16 1420.6
## - sodium.hydroxide.flow           1   0.18 1420.7
## - partial.pressure..DP.            1   0.21 1420.7
## - Pressure.at.the.end.of.the.loop 1   0.24 1420.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.33 1420.8
## - Tempered.Water.Temperature.after.Temped.water.cooler 1   0.33 1420.8
## - Cooling.loop.A.valve.opening..   1   0.40 1420.9
## - ammonia.pump.flow.1             1   0.48 1421.0
## - methane..pressure.to.fermentor.loop.mixture          1   0.50 1421.0
## - Fermentor.fliud.to.ammonia...OD.meter.L.h            1   0.69 1421.2
## - pump.inlet                         1   0.70 1421.2
## - Station.3.Loop.Temperature         1   0.71 1421.2
## - total.air.flow                     1   0.87 1421.3
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 1   0.99 1421.5
## <none>                                1420.5
## - oxygen.flow.stn5                  1   1.37 1421.8
## - dissolved.oxygen.at.stn2          1   1.44 1421.9
## - CH4.in.offgas..                   1   1.76 1422.2
## - oxygen.totaliser                 1   1.84 1422.3
## - Level.on.the.seperator           1   1.86 1422.3

```

## - pressure.at.position.4	1	1.95	1422.4
## - oxygen.flow.stn3	1	2.15	1422.6
## - Station.5.Loop.Temperature	1	2.52	1423.0
## - pump.outlet	1	2.66	1423.1
## - oxygen.flow.stn1	1	3.36	1423.8
## - vessel	1	3.62	1424.1
## - pH.at.stn3	1	3.99	1424.5
## - calcium.chloride.totaliser	1	4.45	1424.9
## - O2.in.offgas..	1	5.55	1426.0
## - Cooling.Water.Return.for.Temped.System	1	6.01	1426.5
## - oxygen.flow.stn4	1	6.30	1426.8
## - Methane.totaliser	1	6.67	1427.2
## - ammonia.totaliser	1	6.87	1427.3
## - methane.flow.stn5	1	6.87	1427.3
## - pH.at.stn5	1	7.67	1428.1
## - methane.flow.stn2	1	8.78	1429.3
## - vent.flow	1	8.89	1429.4
## - oxygen.flow.stn2	1	9.77	1430.2
## - trace.elements.totaliser	1	9.95	1430.4
## - harvest.flow	1	10.20	1430.7
## - EFT..Hours	1	10.92	1431.4
## - ammonia.pump.flow.2	1	13.42	1433.9
## - spare.dosing.pump.flow	1	14.34	1434.8
## - calcium.chloride.flow	1	15.61	1436.1
## - dissolved.oxygen.at.stn5	1	15.85	1436.3
## - methane.flow.stn4	1	17.71	1438.2
## - ferrous.sulphate.totaliser	1	18.32	1438.8
## - methane.flow.stn3	1	20.30	1440.8
## - methane.flow.stn1	1	23.32	1443.8
## - ferrus.sulphate.flow	1	25.80	1446.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.16	1447.6
## - magnesium.potassium.totaliser	1	32.11	1452.6
## - Cooling.loop.B.valve.opening..	1	32.79	1453.3
## - magnesium.potassium.flow	1	54.56	1475.0
## - optical.density	1	54.82	1475.3
## - phosphoric.acid.flow	1	64.09	1484.6
## - phosphoric.acid.totaliser	1	90.50	1511.0
## - dissolved.oxygen.at.stn3	1	103.32	1523.8
## - trace.elements.flow	1	152.52	1573.0
## - dissolved.oxygen.at.stn4	1	203.87	1624.3
## - spare.dosing.pump.totaliser	1	219.34	1639.8
## - sodium.hydroxide.totaliser	1	801.32	2221.8
##		AIC	
## - pH.at.stn1	-775.86		
## - dissolved.oxygen.at.stn1	-775.86		
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer	-775.77		
## - CO2.in.offgas..	-775.62		
## - sodium.hydroxide.flow	-775.60		
## - partial.pressure..DP.	-775.55		
## - Pressure.at.the.end.of.the.loop	-775.50		
## - Tempered.Water.Temperature.before.Temped.water.cooler	-775.37		
## - Tempered.Water.Temperature.after.Temped.water.cooler	-775.37		
## - Cooling.loop.A.valve.opening..	-775.26		
## - ammonia.pump.flow.1	-775.15		

## - methane..pressure.to.fermentor.loop.mixture	-775.11
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-774.82
## - pump.inlet	-774.81
## - Station.3.Loop.Temperature	-774.79
## - total.air.flow	-774.55
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-774.37
## <none>	-773.87
## - oxygen.flow.stn5	-773.79
## - dissolved.oxygen.at.stn2	-773.69
## - CH4.in.offgas..	-773.19
## - oxygen.totaliser	-773.08
## - Level.on.the.seperator	-773.04
## - pressure.at.position.4	-772.91
## - oxygen.flow.stn3	-772.60
## - Station.5.Loop.Temperature	-772.05
## - pump.outlet	-771.84
## - oxygen.flow.stn1	-770.78
## - vessel	-770.38
## - pH.at.stn3	-769.81
## - calcium.chloride.totaliser	-769.13
## - O2.in.offgas..	-767.46
## - Cooling.Water.Return.for.Temped.System	-766.76
## - oxygen.flow.stn4	-766.32
## - Methane.totalier	-765.76
## - ammonia.totalier	-765.45
## - methane.flow.stn5	-765.45
## - pH.at.stn5	-764.25
## - methane.flow.stn2	-762.57
## - vent.flow	-762.40
## - oxygen.flow.stn2	-761.07
## - trace.elements.totaliser	-760.80
## - harvest.flow	-760.42
## - EFT..Hours	-759.34
## - ammonia.pump.flow.2	-755.58
## - spare.dosing.pump.flow	-754.18
## - calcium.chloride.flow	-752.28
## - dissolved.oxygen.at.stn5	-751.92
## - methane.flow.stn4	-749.13
## - ferrous.sulphate.totaliser	-748.21
## - methane.flow.stn3	-745.23
## - methane.flow.stn1	-740.72
## - ferrus.sulphate.flow	-737.02
## - oxygen..pressure.to.fermentor.loop.mixture	-734.98
## - magnesium.potassium.totalier	-727.61
## - Cooling.loop.B.valve.opening..	-726.61
## - magnesium.potassium.flow	-694.49
## - optical.density	-694.12
## - phosphoric.acid.flow	-680.59
## - phosphoric.acid.totaliser	-642.53
## - dissolved.oxygen.at.stn3	-624.28
## - trace.elements.flow	-555.67
## - dissolved.oxygen.at.stn4	-486.32
## - spare.dosing.pump.totaliser	-465.86
## - sodium.hydroxide.totaliser	189.90

```

## 
## Step: AIC=-775.86
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. + dissolved.oxygen.at.stn1 +
## dissolved.oxygen.at.stn2 + dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 +
## dissolved.oxygen.at.stn5 + methane.flow.stn1 + methane.flow.stn2 +
## methane.flow.stn3 + methane.flow.stn4 + methane.flow.stn5 +
## oxygen.flow.stn1 + oxygen.flow.stn2 + oxygen.flow.stn3 +
## oxygen.flow.stn4 + oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.A.Broth.Return.to.Fermenter.mixer +
## CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 + Tempered.Water.Temperature.before.Temped.
## Tempered.Water.Temperature.after.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totaliser +
## spare.dosing.pump.totaliser + ammonia.totaliser + Methane.totaliser +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - dissolved.oxygen.at.stn1          1   0.01 1420.5
## - CoolingLoop.A.Broth.Return.to.Fermenter.mixer      1   0.07 1420.6
## - CO2.in.offgas..                  1   0.16 1420.6
## - sodium.hydroxide.flow           1   0.18 1420.7
## - partial.pressure..DP.            1   0.21 1420.7
## - Pressure.at.the.end.of.the.loop 1   0.24 1420.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.32 1420.8
## - Tempered.Water.Temperature.after.Temped.water.cooler 1   0.34 1420.8
## - Cooling.loop.A.valve.opening..   1   0.40 1420.9
## - ammonia.pump.flow.1             1   0.47 1421.0
## - methane..pressure.to.fermentor.loop.mixture          1   0.49 1421.0
## - Fermentor.fliud.to.ammonia...OD.meter.L.h            1   0.69 1421.2
## - pump.inlet                           1   0.71 1421.2
## - Station.3.Loop.Temperature          1   0.72 1421.2
## - total.air.flow                      1   0.87 1421.3
## - CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 1   0.99 1421.5
## <none>                                1420.5
## - oxygen.flow.stn5                   1   1.36 1421.8
## - dissolved.oxygen.at.stn2          1   1.45 1421.9
## - CH4.in.offgas..                  1   1.76 1422.2
## - oxygen.totaliser                 1   1.85 1422.3
## - Level.on.the.seperator           1   1.86 1422.3
## - pressure.at.position.4            1   1.97 1422.5
## - oxygen.flow.stn3                   1   2.19 1422.7
## - Station.5.Loop.Temperature          1   2.54 1423.0
## - pump.outlet                         1   2.65 1423.1
## - oxygen.flow.stn1                   1   3.35 1423.8
## - vessel                            1   3.63 1424.1

```

## - pH.at.stn3	1	4.53	1425.0
## - calcium.chloride.totaliser	1	4.61	1425.1
## - O2.in.offgas..	1	5.58	1426.1
## - Cooling.Water.Return.for.Temped.System	1	6.00	1426.5
## - oxygen.flow.stn4	1	6.31	1426.8
## - Methane.totalier	1	6.67	1427.2
## - methane.flow.stn5	1	6.86	1427.3
## - ammonia.totalier	1	6.89	1427.4
## - methane.flow.stn2	1	8.78	1429.3
## - vent.flow	1	8.93	1429.4
## - oxygen.flow.stn2	1	9.79	1430.3
## - trace.elements.totaliser	1	9.94	1430.4
## - harvest.flow	1	10.23	1430.7
## - EFT..Hours	1	11.36	1431.8
## - pH.at.stn5	1	12.67	1433.2
## - ammonia.pump.flow.2	1	13.41	1433.9
## - spare.dosing.pump.flow	1	14.55	1435.0
## - dissolved.oxygen.at.stn5	1	15.86	1436.3
## - calcium.chloride.flow	1	15.97	1436.5
## - methane.flow.stn4	1	17.71	1438.2
## - ferrous.sulphate.totaliser	1	18.45	1438.9
## - methane.flow.stn3	1	20.41	1440.9
## - methane.flow.stn1	1	23.33	1443.8
## - ferrus.sulphate.flow	1	25.80	1446.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.15	1447.6
## - magnesium.potassium.totalier	1	32.28	1452.8
## - Cooling.loop.B.valve.opening..	1	32.80	1453.3
## - optical.density	1	54.85	1475.3
## - magnesium.potassium.flow	1	55.83	1476.3
## - phosphoric.acid.flow	1	66.75	1487.2
## - phosphoric.acid.totaliser	1	91.09	1511.6
## - dissolved.oxygen.at.stn3	1	103.41	1523.9
## - trace.elements.flow	1	152.53	1573.0
## - dissolved.oxygen.at.stn4	1	203.88	1624.4
## - spare.dosing.pump.totaliser	1	219.39	1639.9
## - sodium.hydroxide.totaliser	1	844.45	2264.9
##		AIC	
## - dissolved.oxygen.at.stn1		-777.84	
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer		-777.75	
## - CO2.in.offgas..		-777.62	
## - sodium.hydroxide.flow		-777.59	
## - partial.pressure..DP.		-777.53	
## - Pressure.at.the.end.of.the.loop		-777.49	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-777.37	
## - Tempered.Water.Temperature.after.Temped.water.cooler		-777.34	
## - Cooling.loop.A.valve.opening..		-777.25	
## - ammonia.pump.flow.1		-777.14	
## - methane..pressure.to.fermentor.loop.mixture		-777.11	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-776.82	
## - pump.inlet		-776.79	
## - Station.3.Loop.Temperature		-776.76	
## - total.air.flow		-776.54	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117		-776.36	
## <none>		-775.86	

```

## - oxygen.flow.stn5          -775.79
## - dissolved.oxygen.at.stn2   -775.65
## - CH4.in.offgas..            -775.19
## - oxygen.totaliser          -775.05
## - Level.on.the.seperator    -775.04
## - pressure.at.position.4    -774.87
## - oxygen.flow.stn3          -774.53
## - Station.5.Loop.Temperature -774.00
## - pump.outlet                -773.83
## - oxygen.flow.stn1          -772.77
## - vessel                     -772.34
## - pH.at.stn3                 -770.98
## - calcium.chloride.totaliser -770.87
## - O2.in.offgas..             -769.39
## - Cooling.Water.Return.for.Temped.System -768.76
## - oxygen.flow.stn4          -768.28
## - Methane.totalier          -767.74
## - methane.flow.stn5          -767.45
## - ammonia.totalier          -767.41
## - methane.flow.stn2          -764.55
## - vent.flow                  -764.33
## - oxygen.flow.stn2          -763.03
## - trace.elements.totaliser   -762.80
## - harvest.flow               -762.37
## - EFT..Hours                 -760.67
## - pH.at.stn5                 -758.69
## - ammonia.pump.flow.2        -757.57
## - spare.dosing.pump.flow     -755.85
## - dissolved.oxygen.at.stn5   -753.88
## - calcium.chloride.flow      -753.73
## - methane.flow.stn4          -751.11
## - ferrous.sulphate.totaliser -750.00
## - methane.flow.stn3          -747.06
## - methane.flow.stn1          -742.68
## - ferrus.sulphate.flow       -739.00
## - oxygen..pressure.to.fermentor.loop.mixture -736.98
## - magnesium.potassium.totalier -729.35
## - Cooling.loop.B.valve.opening.. -728.58
## - optical.density           -696.06
## - magnesium.potassium.flow   -694.63
## - phosphoric.acid.flow       -678.72
## - phosphoric.acid.totaliser  -643.66
## - dissolved.oxygen.at.stn3   -626.15
## - trace.elements.flow         -557.65
## - dissolved.oxygen.at.stn4   -488.29
## - spare.dosing.pump.totaliser -467.77
## - sodium.hydroxide.totaliser 229.42
##
## Step: AIC=-777.84
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
##           vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
##           Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
##           CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. + dissolved.oxygen.at.stn2 +
##           dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +

```

```

## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.A.Broth.Return.to.Fermenter.mixer +
## CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 + Tempered.Water.Temperature.before.Temped.
## Tempered.Water.Temperature.after.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.A.valve.opening.. + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totaliser +
## spare.dosing.pump.totaliser + ammonia.totaliser + Methane.totaliser +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - CoolingLoop.A.Broth.Return.to.Fermenter.mixer      1   0.07 1420.6
## - CO2.in.offgas..                                1   0.17 1420.7
## - sodium.hydroxide.flow                         1   0.18 1420.7
## - partial.pressure..DP.                          1   0.22 1420.7
## - Pressure.at.the.end.of.the.loop                1   0.24 1420.7
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.32 1420.8
## - Tempered.Water.Temperature.after.Temped.water.cooler 1   0.33 1420.8
## - Cooling.loop.A.valve.opening..                  1   0.39 1420.9
## - ammonia.pump.flow.1                           1   0.48 1421.0
## - methane..pressure.to.fermentor.loop.mixture    1   0.49 1421.0
## - Fermentor.fliud.to.ammonia...OD.meter.L.h       1   0.69 1421.2
## - pump.inlet                                    1   0.70 1421.2
## - Station.3.Loop.Temperature                   1   0.72 1421.2
## - total.air.flow                               1   0.87 1421.4
## - CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 1   0.98 1421.5
## <none>                                         1420.5
## - oxygen.flow.stn5                            1   1.38 1421.9
## - Level.on.the.seperator                     1   1.85 1422.3
## - oxygen.totaliser                          1   1.87 1422.4
## - CH4.in.offgas..                           1   1.92 1422.4
## - pressure.at.position.4                    1   1.98 1422.5
## - oxygen.flow.stn3                            1   2.22 1422.7
## - Station.5.Loop.Temperature                 1   2.53 1423.0
## - pump.outlet                                 1   2.66 1423.2
## - vessel                                      1   3.62 1424.1
## - oxygen.flow.stn1                            1   4.40 1424.9
## - pH.at.stn3                                  1   4.53 1425.0
## - calcium.chloride.totaliser                 1   4.63 1425.1
## - dissolved.oxygen.at.stn2                  1   4.94 1425.4
## - O2.in.offgas..                            1   5.77 1426.3
## - Cooling.Water.Return.for.Temped.System     1   5.99 1426.5
## - oxygen.flow.stn4                            1   6.31 1426.8
## - ammonia.totaliser                        1   6.89 1427.4
## - methane.flow.stn5                           1   6.95 1427.5
## - methane.flow.stn2                           1   9.03 1429.5

```

## - vent.flow	1	9.04	1429.5
## - Methane.totalier	1	9.80	1430.3
## - trace.elements.totaliser	1	9.94	1430.4
## - harvest.flow	1	10.26	1430.8
## - oxygen.flow.stn2	1	10.80	1431.3
## - EFT..Hours	1	11.51	1432.0
## - pH.at.stn5	1	12.70	1433.2
## - ammonia.pump.flow.2	1	13.41	1433.9
## - spare.dosing.pump.flow	1	15.00	1435.5
## - dissolved.oxygen.at.stn5	1	15.85	1436.3
## - calcium.chloride.flow	1	15.96	1436.5
## - methane.flow.stn4	1	17.71	1438.2
## - ferrous.sulphate.totaliser	1	18.44	1438.9
## - methane.flow.stn3	1	20.81	1441.3
## - ferrus.sulphate.flow	1	25.84	1446.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.21	1447.7
## - methane.flow.stn1	1	29.34	1449.8
## - magnesium.potassium.totalier	1	32.28	1452.8
## - Cooling.loop.B.valve.opening..	1	32.92	1453.4
## - optical.density	1	55.11	1475.6
## - magnesium.potassium.flow	1	55.99	1476.5
## - phosphoric.acid.flow	1	67.23	1487.7
## - phosphoric.acid.totaliser	1	91.72	1512.2
## - dissolved.oxygen.at.stn3	1	103.86	1524.4
## - trace.elements.flow	1	152.56	1573.0
## - dissolved.oxygen.at.stn4	1	206.11	1626.6
## - spare.dosing.pump.totaliser	1	221.57	1642.1
## - sodium.hydroxide.totaliser	1	862.69	2283.2
		AIC	
## - Cooling.Loop.A.Broth.Return.to.Fermenter.mixer		-779.74	
## - CO2.in.offgas..		-779.58	
## - sodium.hydroxide.flow		-779.57	
## - partial.pressure..DP.		-779.51	
## - Pressure.at.the.end.of.the.loop		-779.48	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-779.35	
## - Tempered.Water.Temperature.after.Temped.water.cooler		-779.33	
## - Cooling.loop.A.valve.opening..		-779.24	
## - ammonia.pump.flow.1		-779.12	
## - methane..pressure.to.fermentor.loop.mixture		-779.10	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-778.79	
## - pump.inlet		-778.78	
## - Station.3.Loop.Temperature		-778.75	
## - total.air.flow		-778.52	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117		-778.35	
## <none>		-777.84	
## - oxygen.flow.stn5		-777.74	
## - Level.on.the.seperator		-777.02	
## - oxygen.totaliser		-776.99	
## - CH4.in.offgas..		-776.93	
## - pressure.at.position.4		-776.84	
## - oxygen.flow.stn3		-776.47	
## - Station.5.Loop.Temperature		-776.00	
## - pump.outlet		-775.80	
## - vessel		-774.34	

```

## - oxygen.flow.stn1           -773.16
## - pH.at.stn3                -772.97
## - calcium.chloride.totaliser -772.82
## - dissolved.oxygen.at.stn2   -772.35
## - O2.in.offgas..             -771.09
## - Cooling.Water.Return.for.Temped.System -770.76
## - oxygen.flow.stn4           -770.27
## - ammonia.totalier          -769.40
## - methane.flow.stn5          -769.31
## - methane.flow.stn2          -766.16
## - vent.flow                  -766.14
## - Methane.totalier          -765.00
## - trace.elements.totaliser   -764.79
## - harvest.flow               -764.30
## - oxygen.flow.stn2           -763.50
## - EFT..Hours                 -762.42
## - pH.at.stn5                -760.62
## - ammonia.pump.flow.2        -759.56
## - spare.dosing.pump.flow     -757.16
## - dissolved.oxygen.at.stn5   -755.88
## - calcium.chloride.flow      -755.72
## - methane.flow.stn4          -753.09
## - ferrous.sulphate.totaliser -752.00
## - methane.flow.stn3          -748.45
## - ferrus.sulphate.flow       -740.92
## - oxygen..pressure.to.fermentor.loop.mixture -738.88
## - methane.flow.stn1          -735.71
## - magnesium.potassium.totalier -731.33
## - Cooling.loop.B.valve.opening.. -730.38
## - optical.density            -697.66
## - magnesium.potassium.flow   -696.38
## - phosphoric.acid.flow       -680.00
## - phosphoric.acid.totaliser  -644.75
## - dissolved.oxygen.at.stn3   -627.49
## - trace.elements.flow         -559.60
## - dissolved.oxygen.at.stn4   -487.32
## - spare.dosing.pump.totaliser -466.90
## - sodium.hydroxide.totaliser 244.75
##
## Step: AIC=-779.74
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + CO2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Tempered.Water.Temperature.after.Temped.
## Cooling.Water.Return.for.Temped.System + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + Pressure.at.the.end.of.the.loop +

```

```

##   oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
##   partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
##   trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
##   magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
##   sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
##   calcium.chloride.totaliser + magnesium.potassium.totaliser +
##   spare.dosing.pump.totaliser + ammonia.totaliser + Methane.totaliser +
##   oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - C02.in.offgas..                1  0.17 1420.7
## - sodium.hydroxide.flow          1  0.18 1420.7
## - partial.pressure..DP.           1  0.21 1420.8
## - Pressure.at.the.end.of.the.loop 1  0.24 1420.8
## - Tempered.Water.Temperature.after.Temped.water.cooler 1  0.35 1420.9
## - Cooling.loop.A.valve.opening.. 1  0.40 1421.0
## - ammonia.pump.flow.1            1  0.47 1421.0
## - methane..pressure.to.fermentor.loop.mixture             1  0.48 1421.0
## - Tempered.Water.Temperature.before.Temped.water.cooler 1  0.54 1421.1
## - Fermentor.fliud.to.ammonia...OD.meter.L.h              1  0.69 1421.3
## - pump.inlet                           1  0.70 1421.3
## - Station.3.Loop.Temperature          1  0.73 1421.3
## - total.air.flow                      1  0.88 1421.4
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 1  1.11 1421.7
## <none>                                1420.6
## - oxygen.flow.stn5                  1  1.39 1422.0
## - Level.on.the.seperator            1  1.86 1422.4
## - oxygen.totaliser                 1  1.89 1422.5
## - CH4.in.offgas..                  1  1.91 1422.5
## - pressure.at.position.4           1  1.96 1422.5
## - oxygen.flow.stn3                  1  2.23 1422.8
## - Station.5.Loop.Temperature        1  2.52 1423.1
## - pump.outlet                        1  2.69 1423.3
## - vessel                            1  3.60 1424.2
## - oxygen.flow.stn1                  1  4.41 1425.0
## - pH.at.stn3                         1  4.51 1425.1
## - calcium.chloride.totaliser       1  4.66 1425.2
## - dissolved.oxygen.at.stn2         1  4.96 1425.5
## - O2.in.offgas..                   1  5.76 1426.3
## - Cooling.Water.Return.for.Temped.System 1  5.92 1426.5
## - oxygen.flow.stn4                  1  6.30 1426.9
## - ammonia.totalier                 1  6.91 1427.5
## - methane.flow.stn5                1  6.96 1427.5
## - vent.flow                          1  9.02 1429.6
## - methane.flow.stn2                1  9.03 1429.6
## - Methane.totalier                 1  9.81 1430.4
## - trace.elements.totaliser          1 10.00 1430.6
## - harvest.flow                       1 10.27 1430.8
## - oxygen.flow.stn2                  1 10.83 1431.4
## - EFT..Hours                         1 11.45 1432.0
## - pH.at.stn5                         1 12.68 1433.2
## - ammonia.pump.flow.2               1 13.47 1434.0
## - spare.dosing.pump.flow            1 15.05 1435.6
## - dissolved.oxygen.at.stn5          1 15.83 1436.4

```

## - calcium.chloride.flow	1	15.91	1436.5
## - methane.flow.stn4	1	17.67	1438.2
## - ferrous.sulphate.totaliser	1	18.37	1438.9
## - methane.flow.stn3	1	20.86	1441.4
## - ferrus.sulphate.flow	1	25.90	1446.5
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.20	1447.8
## - methane.flow.stn1	1	29.44	1450.0
## - magnesium.potassium.totaliser	1	32.26	1452.8
## - Cooling.loop.B.valve.opening..	1	32.89	1453.5
## - optical.density	1	55.06	1475.6
## - magnesium.potassium.flow	1	56.04	1476.6
## - phosphoric.acid.flow	1	67.27	1487.8
## - phosphoric.acid.totaliser	1	91.69	1512.2
## - dissolved.oxygen.at.stn3	1	104.15	1524.7
## - trace.elements.flow	1	152.55	1573.1
## - dissolved.oxygen.at.stn4	1	206.14	1626.7
## - spare.dosing.pump.totaliser	1	222.08	1642.6
## - sodium.hydroxide.totaliser	1	862.89	2283.5
##		AIC	
## - CO2.in.offgas..		-781.48	
## - sodium.hydroxide.flow		-781.47	
## - partial.pressure..DP.		-781.41	
## - Pressure.at.the.end.of.the.loop		-781.37	
## - Tempered.Water.Temperature.after.Temped.water.cooler		-781.21	
## - Cooling.loop.A.valve.opening..		-781.12	
## - ammonia.pump.flow.1		-781.02	
## - methane..pressure.to.fermentor.loop.mixture		-781.00	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-780.91	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-780.69	
## - pump.inlet		-780.67	
## - Station.3.Loop.Temperature		-780.62	
## - total.air.flow		-780.40	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117		-780.05	
## <none>		-779.74	
## - oxygen.flow.stn5		-779.63	
## - Level.on.the.seperator		-778.91	
## - oxygen.totaliser		-778.87	
## - CH4.in.offgas..		-778.84	
## - pressure.at.position.4		-778.75	
## - oxygen.flow.stn3		-778.35	
## - Station.5.Loop.Temperature		-777.91	
## - pump.outlet		-777.65	
## - vessel		-776.28	
## - oxygen.flow.stn1		-775.04	
## - pH.at.stn3		-774.89	
## - calcium.chloride.totaliser		-774.67	
## - dissolved.oxygen.at.stn2		-774.20	
## - O2.in.offgas..		-773.00	
## - Cooling.Water.Return.for.Temped.System		-772.75	
## - oxygen.flow.stn4		-772.18	
## - ammonia.totaliser		-771.26	
## - methane.flow.stn5		-771.18	
## - vent.flow		-768.08	
## - methane.flow.stn2		-768.05	

```

## - Methane.totalier          -766.88
## - trace.elements.totaliser -766.59
## - harvest.flow             -766.19
## - oxygen.flow.stn2         -765.33
## - EFT..Hours               -764.41
## - pH.at.stn5               -762.55
## - ammonia.pump.flow.2     -761.36
## - spare.dosing.pump.flow  -758.98
## - dissolved.oxygen.at.stn5 -757.81
## - calcium.chloride.flow   -757.69
## - methane.flow.stn4        -755.05
## - ferrous.sulphate.totaliser -754.00
## - methane.flow.stn3        -750.26
## - ferrus.sulphate.flow     -742.73
## - oxygen..pressure.to.fermentor.loop.mixture -740.79
## - methane.flow.stn1        -737.45
## - magnesium.potassium.totalier -733.26
## - Cooling.loop.B.valve.opening.. -732.32
## - optical.density          -699.64
## - magnesium.potassium.flow -698.20
## - phosphoric.acid.flow     -681.84
## - phosphoric.acid.totaliser -646.70
## - dissolved.oxygen.at.stn3 -628.98
## - trace.elements.flow       -561.52
## - dissolved.oxygen.at.stn4 -489.19
## - spare.dosing.pump.totaliser -468.14
## - sodium.hydroxide.totaliser 243.00
##
## Step: AIC=-781.48
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Tempered.Water.Temperature.after.Temped.
## Cooling.Water.Return.for.Temped.System + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + sodium.hydroxide.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totalier +
## spare.dosing.pump.totaliser + ammonia.totalier + Methane.totalier +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - sodium.hydroxide.flow      1    0.18  1420.9

```

## - partial.pressure..DP.	1	0.21	1420.9
## - Pressure.at.the.end.of.the.loop	1	0.24	1421.0
## - Tempered.Water.Temperature.after.Temped.water.cooler	1	0.35	1421.1
## - Cooling.loop.A.valve.opening..	1	0.41	1421.1
## - ammonia.pump.flow.1	1	0.47	1421.2
## - methane..pressure.to.fermentor.loop.mixture	1	0.47	1421.2
## - Tempered.Water.Temperature.before.Temped.water.cooler	1	0.53	1421.3
## - Station.3.Loop.Temperature	1	0.71	1421.5
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	1	0.72	1421.5
## - pump.inlet	1	0.73	1421.5
## - total.air.flow	1	0.89	1421.6
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	1	1.11	1421.8
## <none>			1420.7
## - oxygen.flow.stn5	1	1.36	1422.1
## - CH4.in.offgas..	1	1.74	1422.5
## - oxygen.totaliser	1	1.89	1422.6
## - Level.on.the.seperotor	1	1.90	1422.6
## - pressure.at.position.4	1	1.95	1422.7
## - oxygen.flow.stn3	1	2.32	1423.1
## - Station.5.Loop.Temperature	1	2.51	1423.2
## - pump.outlet	1	2.70	1423.4
## - vessel	1	3.58	1424.3
## - oxygen.flow.stn1	1	4.27	1425.0
## - pH.at.stn3	1	4.58	1425.3
## - calcium.chloride.totaliser	1	4.79	1425.5
## - dissolved.oxygen.at.stn2	1	4.87	1425.6
## - Cooling.Water.Return.for.Temped.System	1	5.95	1426.7
## - O2.in.offgas..	1	6.10	1426.8
## - oxygen.flow.stn4	1	6.18	1426.9
## - ammonia.totalier	1	6.94	1427.7
## - methane.flow.stn5	1	7.00	1427.7
## - vent.flow	1	9.04	1429.8
## - methane.flow.stn2	1	9.32	1430.1
## - Methane.totalier	1	9.76	1430.5
## - trace.elements.totaliser	1	10.18	1430.9
## - harvest.flow	1	10.26	1431.0
## - oxygen.flow.stn2	1	11.12	1431.9
## - EFT..Hours	1	11.48	1432.2
## - pH.at.stn5	1	12.53	1433.3
## - ammonia.pump.flow.2	1	13.50	1434.2
## - spare.dosing.pump.flow	1	15.06	1435.8
## - calcium.chloride.flow	1	15.89	1436.6
## - dissolved.oxygen.at.stn5	1	15.95	1436.7
## - methane.flow.stn4	1	17.55	1438.3
## - ferrous.sulphate.totaliser	1	18.20	1438.9
## - methane.flow.stn3	1	21.07	1441.8
## - ferrus.sulphate.flow	1	25.79	1446.5
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.38	1448.1
## - methane.flow.stn1	1	29.36	1450.1
## - magnesium.potassium.totalier	1	32.11	1452.8
## - Cooling.loop.B.valve.opening..	1	32.96	1453.7
## - optical.density	1	54.89	1475.6
## - magnesium.potassium.flow	1	55.94	1476.7
## - phosphoric.acid.flow	1	67.41	1488.2

## - phosphoric.acid.totaliser	1	91.52	1512.2
## - dissolved.oxygen.at.stn3	1	104.15	1524.9
## - trace.elements.flow	1	152.48	1573.2
## - dissolved.oxygen.at.stn4	1	206.20	1626.9
## - spare.dosing.pump.totaliser	1	221.91	1642.6
## - sodium.hydroxide.totaliser	1	863.50	2284.2
##		AIC	
## - sodium.hydroxide.flow		-783.21	
## - partial.pressure..DP.		-783.16	
## - Pressure.at.the.end.of.the.loop		-783.12	
## - Tempered.Water.Temperature.after.Temped.water.cooler		-782.95	
## - Cooling.loop.A.valve.opening..		-782.86	
## - ammonia.pump.flow.1		-782.76	
## - methane..pressure.to.fermentor.loop.mixture		-782.76	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-782.67	
## - Station.3.Loop.Temperature		-782.39	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-782.38	
## - pump.inlet		-782.37	
## - total.air.flow		-782.13	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117		-781.79	
## <none>		-781.48	
## - oxygen.flow.stn5		-781.41	
## - CH4.in.offgas..		-780.83	
## - oxygen.totaliser		-780.61	
## - Level.on.the.seperator		-780.59	
## - pressure.at.position.4		-780.51	
## - oxygen.flow.stn3		-779.95	
## - Station.5.Loop.Temperature		-779.66	
## - pump.outlet		-779.38	
## - vessel		-778.04	
## - oxygen.flow.stn1		-777.00	
## - pH.at.stn3		-776.52	
## - calcium.chloride.totaliser		-776.20	
## - dissolved.oxygen.at.stn2		-776.09	
## - Cooling.Water.Return.for.Temped.System		-774.45	
## - O2.in.offgas..		-774.22	
## - oxygen.flow.stn4		-774.10	
## - ammonia.totalier		-772.95	
## - methane.flow.stn5		-772.87	
## - vent.flow		-769.78	
## - methane.flow.stn2		-769.35	
## - Methane.totalier		-768.70	
## - trace.elements.totaliser		-768.06	
## - harvest.flow		-767.94	
## - oxygen.flow.stn2		-766.64	
## - EFT..Hours		-766.11	
## - pH.at.stn5		-764.52	
## - ammonia.pump.flow.2		-763.05	
## - spare.dosing.pump.flow		-760.71	
## - calcium.chloride.flow		-759.47	
## - dissolved.oxygen.at.stn5		-759.37	
## - methane.flow.stn4		-756.98	
## - ferrous.sulphate.totaliser		-756.00	
## - methane.flow.stn3		-751.69	

```

## - ferrus.sulphate.flow -744.64
## - oxygen.pressure.to.fermentor.loop.mixture -742.26
## - methane.flow.stn1 -739.31
## - magnesium.potassium.totalier -735.22
## - Cooling.loop.B.valve.opening.. -733.97
## - optical.density -701.63
## - magnesium.potassium.flow -700.09
## - phosphoric.acid.flow -683.39
## - phosphoric.acid.totaliser -648.70
## - dissolved.oxygen.at.stn3 -630.75
## - trace.elements.flow -563.37
## - dissolved.oxygen.at.stn4 -490.88
## - spare.dosing.pump.totaliser -470.14
## - sodium.hydroxide.totaliser 241.73
##
## Step: AIC=-783.21
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Tempered.Water.Temperature.after.Temped.
## Cooling.Water.Return.for.Temped.System + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen.pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## partial.pressure..DP. + phosphoric.acid.flow + trace.elements.flow +
## ferrus.sulphate.flow + calcium.chloride.flow + magnesium.potassium.flow +
## spare.dosing.pump.flow + phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totalier + spare.dosing.pump.totaliser +
## ammonia.totalier + Methane.totalier + oxygen.totaliser +
## Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - partial.pressure..DP.          1   0.20 1421.1
## - Pressure.at.the.end.of.the.loop 1   0.24 1421.2
## - Tempered.Water.Temperature.after.Temped.water.cooler 1   0.37 1421.3
## - Cooling.loop.A.valve.opening.. 1   0.41 1421.3
## - ammonia.pump.flow.1           1   0.46 1421.4
## - methane..pressure.to.fermentor.loop.mixture            1   0.46 1421.4
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.51 1421.4
## - Station.3.Loop.Temperature             1   0.71 1421.6
## - Fermentor.fliud.to.ammonia...OD.meter.L.h            1   0.72 1421.6
## - pump.inlet                         1   0.73 1421.7
## - total.air.flow                      1   0.87 1421.8
## - CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 1   1.08 1422.0
## <none>                                1420.9
## - oxygen.flow.stn5                  1   1.34 1422.2

```

## - CH4.in.offgas..	1	1.76	1422.7
## - Level.on.the.seperator	1	1.89	1422.8
## - oxygen.totaliser	1	1.90	1422.8
## - pressure.at.position.4	1	1.95	1422.9
## - oxygen.flow.stn3	1	2.32	1423.2
## - Station.5.Loop.Temperature	1	2.47	1423.4
## - pump.outlet	1	2.71	1423.6
## - vessel	1	3.65	1424.6
## - oxygen.flow.stn1	1	4.31	1425.2
## - pH.at.stn3	1	4.55	1425.5
## - calcium.chloride.totaliser	1	4.82	1425.7
## - dissolved.oxygen.at.stn2	1	4.91	1425.8
## - Cooling.Water.Return.for.Temped.System	1	6.05	1427.0
## - O2.in.offgas..	1	6.08	1427.0
## - oxygen.flow.stn4	1	6.18	1427.1
## - methane.flow.stn5	1	6.95	1427.9
## - ammonia.totalier	1	6.99	1427.9
## - vent.flow	1	9.13	1430.0
## - methane.flow.stn2	1	9.35	1430.3
## - Methane.totalier	1	9.79	1430.7
## - trace.elements.totaliser	1	10.19	1431.1
## - harvest.flow	1	10.31	1431.2
## - oxygen.flow.stn2	1	11.15	1432.1
## - EFT..Hours	1	11.52	1432.4
## - pH.at.stn5	1	12.59	1433.5
## - ammonia.pump.flow.2	1	13.53	1434.4
## - spare.dosing.pump.flow	1	15.13	1436.0
## - dissolved.oxygen.at.stn5	1	15.95	1436.9
## - calcium.chloride.flow	1	15.98	1436.9
## - methane.flow.stn4	1	17.55	1438.5
## - ferrous.sulphate.totaliser	1	18.16	1439.1
## - methane.flow.stn3	1	21.04	1442.0
## - ferrus.sulphate.flow	1	25.67	1446.6
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.31	1448.2
## - methane.flow.stn1	1	29.54	1450.5
## - magnesium.potassium.totalier	1	32.29	1453.2
## - Cooling.loop.B.valve.opening..	1	33.04	1454.0
## - optical.density	1	54.81	1475.7
## - magnesium.potassium.flow	1	55.87	1476.8
## - phosphoric.acid.flow	1	67.33	1488.2
## - phosphoric.acid.totaliser	1	91.62	1512.5
## - dissolved.oxygen.at.stn3	1	104.09	1525.0
## - trace.elements.flow	1	152.35	1573.3
## - dissolved.oxygen.at.stn4	1	206.26	1627.2
## - spare.dosing.pump.totaliser	1	222.21	1643.1
## - sodium.hydroxide.totaliser	1	863.61	2284.5
##		AIC	
## - partial.pressure..DP.	-784.91		
## - Pressure.at.the.end.of.the.loop	-784.85		
## - Tempered.Water.Temperature.after.Temped.water.cooler	-784.64		
## - Cooling.loop.A.valve.opening..	-784.58		
## - ammonia.pump.flow.1	-784.51		
## - methane..pressure.to.fermentor.loop.mixture	-784.51		
## - Tempered.Water.Temperature.before.Temped.water.cooler	-784.43		

## - Station.3.Loop.Temperature	-784.13
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-784.11
## - pump.inlet	-784.09
## - total.air.flow	-783.88
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-783.56
## <none>	-783.21
## - oxygen.flow.stn5	-783.17
## - CH4.in.offgas..	-782.54
## - Level.on.the.seperator	-782.33
## - oxygen.totaliser	-782.32
## - pressure.at.position.4	-782.25
## - oxygen.flow.stn3	-781.68
## - Station.5.Loop.Temperature	-781.46
## - pump.outlet	-781.09
## - vessel	-779.66
## - oxygen.flow.stn1	-778.66
## - pH.at.stn3	-778.31
## - calcium.chloride.totaliser	-777.90
## - dissolved.oxygen.at.stn2	-777.75
## - Cooling.Water.Return.for.Temped.System	-776.03
## - O2.in.offgas..	-775.99
## - oxygen.flow.stn4	-775.84
## - methane.flow.stn5	-774.66
## - ammonia.totalier	-774.61
## - vent.flow	-771.38
## - methane.flow.stn2	-771.04
## - Methane.totalier	-770.38
## - trace.elements.totaliser	-769.77
## - harvest.flow	-769.60
## - oxygen.flow.stn2	-768.33
## - EFT..Hours	-767.78
## - pH.at.stn5	-766.16
## - ammonia.pump.flow.2	-764.75
## - spare.dosing.pump.flow	-762.34
## - dissolved.oxygen.at.stn5	-761.11
## - calcium.chloride.flow	-761.06
## - methane.flow.stn4	-758.70
## - ferrous.sulphate.totaliser	-757.79
## - methane.flow.stn3	-753.47
## - ferrus.sulphate.flow	-746.55
## - oxygen..pressure.to.fermentor.loop.mixture	-744.11
## - methane.flow.stn1	-740.78
## - magnesium.potassium.totalier	-736.70
## - Cooling.loop.B.valve.opening..	-735.57
## - optical.density	-703.49
## - magnesium.potassium.flow	-701.94
## - phosphoric.acid.flow	-685.25
## - phosphoric.acid.totaliser	-650.30
## - dissolved.oxygen.at.stn3	-632.57
## - trace.elements.flow	-565.31
## - dissolved.oxygen.at.stn4	-492.56
## - spare.dosing.pump.totaliser	-471.51
## - sodium.hydroxide.totaliser	240.01
##	

```

## Step: AIC=-784.91
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Tempered.Water.Temperature.after.Temped.w
## Cooling.Water.Return.for.Temped.System + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + Pressure.at.the.end.of.the.loop +
## oxygen..pressure.to.fermentor.loop.mixture + methane..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
## ammonia.totaliser + Methane.totaliser + oxygen.totaliser +
## Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - Pressure.at.the.end.of.the.loop      1   0.24 1421.3
## - Tempered.Water.Temperature.after.Temped.water.cooler  1   0.38 1421.5
## - Cooling.loop.A.valve.opening..       1   0.41 1421.5
## - methane..pressure.to.fermentor.loop.mixture      1   0.47 1421.6
## - ammonia.pump.flow.1                 1   0.47 1421.6
## - Tempered.Water.Temperature.before.Temped.water.cooler  1   0.51 1421.6
## - Station.3.Loop.Temperature          1   0.73 1421.8
## - Fermentor.fliud.to.ammonia...OD.meter.L.h        1   0.75 1421.9
## - pump.inlet                         1   0.75 1421.9
## - total.air.flow                     1   0.86 1422.0
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117  1   1.10 1422.2
## <none>                                1421.1
## - oxygen.flow.stn5                  1   1.35 1422.5
## - CH4.in.offgas..                   1   1.72 1422.8
## - oxygen.totaliser                 1   1.93 1423.0
## - Level.on.the.seperator           1   1.94 1423.0
## - pressure.at.position.4           1   1.97 1423.1
## - oxygen.flow.stn3                  1   2.32 1423.4
## - Station.5.Loop.Temperature        1   2.47 1423.6
## - pump.outlet                      1   2.76 1423.9
## - vessel                           1   3.73 1424.8
## - oxygen.flow.stn1                  1   4.26 1425.4
## - pH.at.stn3                       1   4.64 1425.8
## - calcium.chloride.totaliser       1   4.78 1425.9
## - dissolved.oxygen.at.stn2         1   4.86 1426.0
## - Cooling.Water.Return.for.Temped.System  1   5.96 1427.1
## - O2.in.offgas..                   1   5.97 1427.1
## - oxygen.flow.stn4                  1   6.16 1427.3
## - ammonia.totaliser                1   6.96 1428.1

```

## - methane.flow.stn5	1	7.00	1428.1
## - vent.flow	1	9.22	1430.3
## - methane.flow.stn2	1	9.29	1430.4
## - Methane.totaliser	1	9.98	1431.1
## - trace.elements.totaliser	1	10.09	1431.2
## - harvest.flow	1	10.39	1431.5
## - oxygen.flow.stn2	1	11.13	1432.2
## - EFT..Hours	1	11.45	1432.6
## - pH.at.stn5	1	12.50	1433.6
## - ammonia.pump.flow.2	1	13.52	1434.6
## - spare.dosing.pump.flow	1	15.10	1436.2
## - calcium.chloride.flow	1	16.01	1437.1
## - dissolved.oxygen.at.stn5	1	16.03	1437.1
## - methane.flow.stn4	1	17.57	1438.7
## - ferrous.sulphate.totaliser	1	18.41	1439.5
## - methane.flow.stn3	1	20.89	1442.0
## - ferrus.sulphate.flow	1	25.58	1446.7
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.37	1448.5
## - methane.flow.stn1	1	29.45	1450.6
## - magnesium.potassium.totaliser	1	32.31	1453.4
## - Cooling.loop.B.valve.opening..	1	33.11	1454.2
## - optical.density	1	55.50	1476.6
## - magnesium.potassium.flow	1	55.84	1477.0
## - phosphoric.acid.flow	1	67.44	1488.5
## - phosphoric.acid.totaliser	1	92.08	1513.2
## - dissolved.oxygen.at.stn3	1	103.96	1525.1
## - trace.elements.flow	1	152.28	1573.4
## - dissolved.oxygen.at.stn4	1	206.21	1627.3
## - spare.dosing.pump.totaliser	1	222.01	1643.1
## - sodium.hydroxide.totaliser	1	863.89	2285.0
##		AIC	
## - Pressure.at.the.end.of.the.loop		-786.54	
## - Tempered.Water.Temperature.after.Temped.water.cooler		-786.32	
## - Cooling.loop.A.valve.opening..		-786.29	
## - methane..pressure.to.fermentor.loop.mixture		-786.20	
## - ammonia.pump.flow.1		-786.19	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-786.14	
## - Station.3.Loop.Temperature		-785.79	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-785.77	
## - pump.inlet		-785.77	
## - total.air.flow		-785.61	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117		-785.24	
## <none>		-784.91	
## - oxygen.flow.stn5		-784.86	
## - CH4.in.offgas..		-784.29	
## - oxygen.totaliser		-783.97	
## - Level.on.the.seperator		-783.96	
## - pressure.at.position.4		-783.91	
## - oxygen.flow.stn3		-783.38	
## - Station.5.Loop.Temperature		-783.16	
## - pump.outlet		-782.72	
## - vessel		-781.24	
## - oxygen.flow.stn1		-780.45	
## - pH.at.stn3		-779.87	

```

## - calcium.chloride.totaliser          -779.66
## - dissolved.oxygen.at.stn2           -779.53
## - Cooling.Water.Return.for.Temped.System -777.87
## - O2.in.offgas..                     -777.85
## - oxygen.flow.stn4                  -777.56
## - ammonia.totalier                 -776.35
## - methane.flow.stn5                  -776.30
## - vent.flow                         -772.94
## - methane.flow.stn2                  -772.84
## - Methane.totalier                  -771.80
## - trace.elements.totaliser          -771.64
## - harvest.flow                      -771.17
## - oxygen.flow.stn2                  -770.06
## - EFT..Hours                        -769.58
## - pH.at.stn5                        -768.00
## - ammonia.pump.flow.2              -766.46
## - spare.dosing.pump.flow          -764.09
## - calcium.chloride.flow            -762.72
## - dissolved.oxygen.at.stn5          -762.69
## - methane.flow.stn4                -760.37
## - ferrous.sulphate.totaliser       -759.12
## - methane.flow.stn3                -755.40
## - ferrus.sulphate.flow             -748.39
## - oxygen..pressure.to.fermentor.loop.mixture -745.72
## - methane.flow.stn1                -742.63
## - magnesium.potassium.totalier    -738.36
## - Cooling.loop.B.valve.opening..   -737.19
## - optical.density                 -704.19
## - magnesium.potassium.flow        -703.70
## - phosphoric.acid.flow            -686.81
## - phosphoric.acid.totaliser       -651.36
## - dissolved.oxygen.at.stn3         -634.48
## - trace.elements.flow              -567.13
## - dissolved.oxygen.at.stn4          -494.37
## - spare.dosing.pump.totaliser     -473.51
## - sodium.hydroxide.totaliser      238.46
##
## Step: AIC=-786.54
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Tempered.Water.Temperature.after.Temped.
## Cooling.Water.Return.for.Temped.System + Cooling.loop.A.valve.opening.. +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## methane..pressure.to.fermentor.loop.mixture + phosphoric.acid.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +

```

```

##      magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
##      sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
##      calcium.chloride.totaliser + magnesium.potassium.totalier +
##      spare.dosing.pump.totaliser + ammonia.totalier + Methane.totalier +
##      oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - Cooling.loop.A.valve.opening..          1   0.38 1421.7
## - Tempered.Water.Temperature.after.Temped.water.cooler  1   0.39 1421.7
## - ammonia.pump.flow.1                  1   0.47 1421.8
## - methane..pressure.to.fermentor.loop.mixture       1   0.48 1421.8
## - Tempered.Water.Temperature.before.Temped.water.cooler  1   0.50 1421.8
## - Station.3.Loop.Temperature           1   0.73 1422.1
## - Fermentor.fliud.to.ammonia...OD.meter.L.h        1   0.78 1422.1
## - total.air.flow                      1   1.05 1422.4
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117  1   1.09 1422.4
## - pump.inlet                           1   1.10 1422.5
## <none>                                1421.3
## - oxygen.flow.stn5                   1   1.33 1422.7
## - CH4.in.offgas..                    1   1.65 1423.0
## - pressure.at.position.4            1   1.95 1423.3
## - oxygen.totaliser                 1   1.99 1423.3
## - Level.on.the.seperator           1   2.03 1423.4
## - oxygen.flow.stn3                  1   2.41 1423.8
## - Station.5.Loop.Temperature        1   2.42 1423.8
## - pump.outlet                        1   2.74 1424.1
## - vessel                             1   3.80 1425.2
## - oxygen.flow.stn1                  1   4.17 1425.5
## - pH.at.stn3                         1   4.70 1426.0
## - calcium.chloride.totaliser        1   4.73 1426.1
## - dissolved.oxygen.at.stn2          1   4.83 1426.2
## - Cooling.Water.Return.for.Temped.System  1   5.91 1427.3
## - oxygen.flow.stn4                  1   6.04 1427.4
## - O2.in.offgas..                   1   6.10 1427.5
## - ammonia.totalier                 1   6.97 1428.3
## - methane.flow.stn5                1   6.99 1428.3
## - vent.flow                          1   9.02 1430.4
## - methane.flow.stn2                1   9.24 1430.6
## - Methane.totalier                  1   9.94 1431.3
## - trace.elements.totaliser          1  10.04 1431.4
## - harvest.flow                      1  10.36 1431.7
## - oxygen.flow.stn2                  1  11.15 1432.5
## - EFT..Hours                        1  11.38 1432.7
## - pH.at.stn5                        1  12.42 1433.8
## - ammonia.pump.flow.2              1  13.49 1434.8
## - spare.dosing.pump.flow           1  15.12 1436.5
## - calcium.chloride.flow            1  15.89 1437.2
## - dissolved.oxygen.at.stn5          1  16.13 1437.5
## - methane.flow.stn4                1  17.42 1438.8
## - ferrous.sulphate.totaliser       1  18.55 1439.9
## - methane.flow.stn3                1  21.17 1442.5
## - ferrus.sulphate.flow             1  25.96 1447.3
## - oxygen..pressure.to.fermentor.loop.mixture  1  27.26 1448.6
## - methane.flow.stn1                1  29.32 1450.7

```

## - magnesium.potassium.totalier	1	32.46	1453.8
## - Cooling.loop.B.valve.opening..	1	33.53	1454.9
## - optical.density	1	55.63	1477.0
## - magnesium.potassium.flow	1	55.91	1477.3
## - phosphoric.acid.flow	1	67.73	1489.1
## - phosphoric.acid.totaliser	1	92.61	1514.0
## - dissolved.oxygen.at.stn3	1	104.37	1525.7
## - trace.elements.flow	1	153.43	1574.8
## - dissolved.oxygen.at.stn4	1	206.47	1627.8
## - spare.dosing.pump.totaliser	1	222.35	1643.7
## - sodium.hydroxide.totaliser	1	868.01	2289.4
##		AIC	
## - Cooling.loop.A.valve.opening..		-787.97	
## - Tempered.Water.Temperature.after.Temped.water.cooler		-787.95	
## - ammonia.pump.flow.1		-787.82	
## - methane..pressure.to.fermentor.loop.mixture		-787.81	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-787.78	
## - Station.3.Loop.Temperature		-787.43	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-787.36	
## - total.air.flow		-786.95	
## - CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117		-786.89	
## - pump.inlet		-786.87	
## <none>		-786.54	
## - oxygen.flow.stn5		-786.53	
## - CH4.in.offgas..		-786.03	
## - pressure.at.position.4		-785.58	
## - oxygen.totaliser		-785.52	
## - Level.on.the.seperator		-785.46	
## - oxygen.flow.stn3		-784.88	
## - Station.5.Loop.Temperature		-784.87	
## - pump.outlet		-784.38	
## - vessel		-782.78	
## - oxygen.flow.stn1		-782.21	
## - pH.at.stn3		-781.42	
## - calcium.chloride.totaliser		-781.36	
## - dissolved.oxygen.at.stn2		-781.22	
## - Cooling.Water.Return.for.Temped.System		-779.58	
## - oxygen.flow.stn4		-779.39	
## - O2.in.offgas..		-779.30	
## - ammonia.totalier		-777.97	
## - methane.flow.stn5		-777.94	
## - vent.flow		-774.88	
## - methane.flow.stn2		-774.55	
## - Methane.totalier		-773.49	
## - trace.elements.totaliser		-773.34	
## - harvest.flow		-772.86	
## - oxygen.flow.stn2		-771.66	
## - EFT..Hours		-771.32	
## - pH.at.stn5		-769.76	
## - ammonia.pump.flow.2		-768.14	
## - spare.dosing.pump.flow		-765.69	
## - calcium.chloride.flow		-764.54	
## - dissolved.oxygen.at.stn5		-764.18	
## - methane.flow.stn4		-762.24	

```

## - ferrous.sulphate.totaliser          -760.54
## - methane.flow.stn3                  -756.62
## - ferrus.sulphate.flow              -749.47
## - oxygen..pressure.to.fermentor.loop.mixture -747.53
## - methane.flow.stn1                  -744.46
## - magnesium.potassium.totalier     -739.79
## - Cooling.loop.B.valve.opening..    -738.20
## - optical.density                  -705.65
## - magnesium.potassium.flow         -705.24
## - phosphoric.acid.flow             -688.04
## - phosphoric.acid.totaliser       -652.26
## - dissolved.oxygen.at.stn3        -635.55
## - trace.elements.flow              -567.22
## - dissolved.oxygen.at.stn4        -495.71
## - spare.dosing.pump.totaliser     -474.75
## - sodium.hydroxide.totaliser      240.58
##
## Step: AIC=-787.97
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Tempered.water.cooler + Tempered.Water.Temperature.after.Tempered.
## Cooling.Water.Return.for.Tempered.System + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## methane..pressure.to.fermentor.loop.mixture + phosphoric.acid.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totalier +
## spare.dosing.pump.totaliser + ammonia.totalier + Methane.totalier +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq   RSS
## - Tempered.Water.Temperature.after.Tempered.water.cooler  1   0.27 1422.0
## - methane..pressure.to.fermentor.loop.mixture            1   0.38 1422.1
## - ammonia.pump.flow.1                                 1   0.47 1422.2
## - Tempered.Water.Temperature.before.Tempered.water.cooler 1   0.52 1422.2
## - Station.3.Loop.Temperature                         1   0.76 1422.5
## - Fermentor.fliud.to.ammonia...OD.meter.L.h           1   0.76 1422.5
## - total.air.flow                                    1   1.05 1422.8
## - CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 1   1.06 1422.8
## - pump.inlet                                       1   1.13 1422.9
## <none>                                         1421.7
## - oxygen.flow.stn5                                1   1.51 1423.2
## - CH4.in.offgas..                                1   1.66 1423.4
## - pressure.at.position.4                          1   1.74 1423.5
## - Level.on.the.seperator                        1   2.04 1423.8

```

## - oxygen.totaliser	1	2.05	1423.8
## - Station.5.Loop.Temperature	1	2.43	1424.2
## - pump.outlet	1	2.66	1424.4
## - oxygen.flow.stn3	1	2.83	1424.6
## - vessel	1	3.63	1425.4
## - oxygen.flow.stn1	1	4.00	1425.7
## - calcium.chloride.totaliser	1	4.52	1426.2
## - dissolved.oxygen.at.stn2	1	4.61	1426.3
## - pH.at.stn3	1	4.76	1426.5
## - Cooling.Water.Return.for.Temped.System	1	5.64	1427.4
## - oxygen.flow.stn4	1	5.83	1427.6
## - O2.in.offgas..	1	6.08	1427.8
## - ammonia.totaliser	1	7.05	1428.8
## - methane.flow.stn5	1	7.77	1429.5
## - vent.flow	1	8.69	1430.4
## - methane.flow.stn2	1	9.31	1431.0
## - trace.elements.totaliser	1	9.88	1431.6
## - harvest.flow	1	10.03	1431.8
## - Methane.totaliser	1	10.27	1432.0
## - EFT..Hours	1	11.00	1432.7
## - oxygen.flow.stn2	1	11.37	1433.1
## - pH.at.stn5	1	12.46	1434.2
## - ammonia.pump.flow.2	1	13.51	1435.2
## - spare.dosing.pump.flow	1	15.26	1437.0
## - calcium.chloride.flow	1	16.70	1438.4
## - dissolved.oxygen.at.stn5	1	16.70	1438.4
## - methane.flow.stn4	1	17.26	1439.0
## - ferrous.sulphate.totaliser	1	19.40	1441.1
## - methane.flow.stn3	1	23.42	1445.2
## - ferrus.sulphate.flow	1	26.53	1448.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	26.88	1448.6
## - methane.flow.stn1	1	29.09	1450.8
## - magnesium.potassium.totaliser	1	32.61	1454.3
## - optical.density	1	55.58	1477.3
## - magnesium.potassium.flow	1	57.97	1479.7
## - phosphoric.acid.flow	1	74.08	1495.8
## - Cooling.loop.B.valve.opening..	1	89.86	1511.6
## - phosphoric.acid.totaliser	1	93.57	1515.3
## - dissolved.oxygen.at.stn3	1	104.00	1525.7
## - trace.elements.flow	1	154.25	1576.0
## - dissolved.oxygen.at.stn4	1	206.20	1627.9
## - spare.dosing.pump.totaliser	1	222.22	1644.0
## - sodium.hydroxide.totaliser	1	870.63	2292.4
##		AIC	
## - Tempered.Water.Temperature.after.Temped.water.cooler	-789.56		
## - methane..pressure.to.fermentor.loop.mixture	-789.39		
## - ammonia.pump.flow.1	-789.26		
## - Tempered.Water.Temperature.before.Temped.water.cooler	-789.18		
## - Station.3.Loop.Temperature	-788.82		
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-788.81		
## - total.air.flow	-788.38		
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-788.36		
## - pump.inlet	-788.25		
## <none>	-787.97		

```

## - oxygen.flow.stn5          -787.68
## - CH4.in.offgas..           -787.45
## - pressure.at.position.4    -787.32
## - Level.on.the.seperator    -786.87
## - oxygen.totaliser          -786.85
## - Station.5.Loop.Temperature -786.28
## - pump.outlet                -785.94
## - oxygen.flow.stn3           -785.68
## - vessel                      -784.46
## - oxygen.flow.stn1           -783.90
## - calcium.chloride.totaliser -783.12
## - dissolved.oxygen.at.stn2   -782.98
## - pH.at.stn3                 -782.76
## - Cooling.Water.Return.for.Temped.System -781.43
## - oxygen.flow.stn4           -781.13
## - O2.in.offgas..             -780.75
## - ammonia.totalier           -779.30
## - methane.flow.stn5          -778.20
## - vent.flow                   -776.81
## - methane.flow.stn2          -775.87
## - trace.elements.totaliser   -775.01
## - harvest.flow                -774.79
## - Methane.totalier           -774.43
## - EFT..Hours                  -773.32
## - oxygen.flow.stn2           -772.78
## - pH.at.stn5                 -771.13
## - ammonia.pump.flow.2        -769.54
## - spare.dosing.pump.flow     -766.92
## - calcium.chloride.flow      -764.75
## - dissolved.oxygen.at.stn5   -764.75
## - methane.flow.stn4          -763.92
## - ferrous.sulphate.totaliser -760.71
## - methane.flow.stn3           -754.69
## - ferrus.sulphate.flow        -750.05
## - oxygen..pressure.to.fermentor.loop.mixture -749.52
## - methane.flow.stn1           -746.24
## - magnesium.potassium.totalier -741.00
## - optical.density            -707.17
## - magnesium.potassium.flow   -703.68
## - phosphoric.acid.flow       -680.30
## - Cooling.loop.B.valve.opening.. -657.65
## - phosphoric.acid.totaliser  -652.36
## - dissolved.oxygen.at.stn3   -637.55
## - trace.elements.flow         -567.58
## - dissolved.oxygen.at.stn4   -497.56
## - spare.dosing.pump.totaliser -476.42
## - sodium.hydroxide.totaliser 241.41
##
## Step: AIC=-789.56
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
##           vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
##           Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
##           CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
##           dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +

```

```

## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## methane..pressure.to.fermentor.loop.mixture + phosphoric.acid.flow +
## trace.elements.flow + ferrus.sulphate.flow + calcium.chloride.flow +
## magnesium.potassium.flow + spare.dosing.pump.flow + phosphoric.acid.totaliser +
## sodium.hydroxide.totaliser + trace.elements.totaliser + ferrous.sulphate.totaliser +
## calcium.chloride.totaliser + magnesium.potassium.totaliser +
## spare.dosing.pump.totaliser + ammonia.totaliser + Methane.totaliser +
## oxygen.totaliser + Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - methane..pressure.to.fermentor.loop.mixture      1   0.38 1422.4
## - ammonia.pump.flow.1                            1   0.46 1422.5
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.53 1422.5
## - Station.3.Loop.Temperature                      1   0.73 1422.7
## - Fermentor.fliud.to.ammonia...OD.meter.L.h       1   0.75 1422.7
## - CoolingLoop.B.Broth.Return.to.Fermenter.mixer.J1117 1   0.95 1423.0
## - total.air.flow                                1   1.05 1423.0
## - pump.inlet                                    1   1.13 1423.1
## <none>                                         1422.0
## - oxygen.flow.stn5                            1   1.56 1423.5
## - CH4.in.offgas..                           1   1.71 1423.7
## - pressure.at.position.4                     1   1.73 1423.7
## - oxygen.totaliser                          1   2.01 1424.0
## - Level.on.the.seperator                   1   2.11 1424.1
## - Station.5.Loop.Temperature                1   2.34 1424.3
## - pump.outlet                               1   2.75 1424.7
## - oxygen.flow.stn3                            1   2.81 1424.8
## - vessel                                     1   3.47 1425.5
## - oxygen.flow.stn1                            1   4.05 1426.0
## - dissolved.oxygen.at.stn2                 1   4.52 1426.5
## - calcium.chloride.totaliser                1   4.56 1426.5
## - pH.at.stn3                                1   4.82 1426.8
## - oxygen.flow.stn4                            1   5.84 1427.8
## - Cooling.Water.Return.for.Temped.System     1   5.97 1428.0
## - O2.in.offgas..                           1   6.09 1428.1
## - ammonia.totalier                         1   7.08 1429.1
## - methane.flow.stn5                          1   7.88 1429.9
## - vent.flow                                 1   9.07 1431.1
## - methane.flow.stn2                          1   9.35 1431.3
## - trace.elements.totaliser                  1   9.98 1432.0
## - harvest.flow                             1   10.01 1432.0
## - Methane.totalier                         1   10.20 1432.2
## - EFT..Hours                                1   11.04 1433.0
## - oxygen.flow.stn2                           1   11.33 1433.3
## - pH.at.stn5                                1   12.32 1434.3
## - ammonia.pump.flow.2                      1   13.62 1435.6
## - spare.dosing.pump.flow                  1   15.28 1437.3

```

## - calcium.chloride.flow	1	16.70	1438.7
## - dissolved.oxygen.at.stn5	1	16.76	1438.8
## - methane.flow.stn4	1	17.28	1439.3
## - ferrous.sulphate.totaliser	1	19.22	1441.2
## - methane.flow.stn3	1	23.44	1445.4
## - ferrus.sulphate.flow	1	26.26	1448.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.06	1449.1
## - methane.flow.stn1	1	29.25	1451.2
## - magnesium.potassium.totaliser	1	32.63	1454.6
## - optical.density	1	55.51	1477.5
## - magnesium.potassium.flow	1	57.86	1479.8
## - phosphoric.acid.flow	1	73.83	1495.8
## - Cooling.loop.B.valve.opening..	1	90.17	1512.2
## - phosphoric.acid.totaliser	1	93.43	1515.4
## - dissolved.oxygen.at.stn3	1	103.77	1525.8
## - trace.elements.flow	1	154.03	1576.0
## - dissolved.oxygen.at.stn4	1	205.96	1628.0
## - spare.dosing.pump.totaliser	1	222.20	1644.2
## - sodium.hydroxide.totaliser	1	870.60	2292.6
##		AIC	
## - methane..pressure.to.fermentor.loop.mixture		-790.99	
## - ammonia.pump.flow.1		-790.87	
## - Tempered.Water.Temperature.before.Temped.water.cooler		-790.76	
## - Station.3.Loop.Temperature		-790.46	
## - Fermentor.fliud.to.ammonia...OD.meter.L.h		-790.43	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117		-790.12	
## - total.air.flow		-789.98	
## - pump.inlet		-789.85	
## <none>		-789.56	
## - oxygen.flow.stn5		-789.20	
## - CH4.in.offgas..		-788.97	
## - pressure.at.position.4		-788.93	
## - oxygen.totaliser		-788.51	
## - Level.on.the.seperator		-788.36	
## - Station.5.Loop.Temperature		-788.01	
## - pump.outlet		-787.40	
## - oxygen.flow.stn3		-787.31	
## - vessel		-786.31	
## - oxygen.flow.stn1		-785.42	
## - dissolved.oxygen.at.stn2		-784.71	
## - calcium.chloride.totaliser		-784.66	
## - pH.at.stn3		-784.26	
## - oxygen.flow.stn4		-782.71	
## - Cooling.Water.Return.for.Temped.System		-782.52	
## - O2.in.offgas..		-782.34	
## - ammonia.totaliser		-780.84	
## - methane.flow.stn5		-779.63	
## - vent.flow		-777.83	
## - methane.flow.stn2		-777.41	
## - trace.elements.totaliser		-776.47	
## - harvest.flow		-776.42	
## - Methane.totalier		-776.14	
## - EFT..Hours		-774.87	
## - oxygen.flow.stn2		-774.42	

```

## - pH.at.stn5                                -772.93
## - ammonia.pump.flow.2                      -770.99
## - spare.dosing.pump.flow                  -768.49
## - calcium.chloride.flow                   -766.35
## - dissolved.oxygen.at.stn5                -766.26
## - methane.flow.stn4                       -765.48
## - ferrous.sulphate.totaliser             -762.58
## - methane.flow.stn3                       -756.27
## - ferrus.sulphate.flow                   -752.05
## - oxygen..pressure.to.fermentor.loop.mixture -750.86
## - methane.flow.stn1                       -747.61
## - magnesium.potassium.totalier          -742.58
## - optical.density                        -708.89
## - magnesium.potassium.flow              -705.46
## - phosphoric.acid.flow                  -682.29
## - Cooling.loop.B.valve.opening..        -658.82
## - phosphoric.acid.totaliser            -654.18
## - dissolved.oxygen.at.stn3              -639.50
## - trace.elements.flow                  -569.52
## - dissolved.oxygen.at.stn4              -499.53
## - spare.dosing.pump.totaliser          -478.10
## - sodium.hydroxide.totaliser           239.62
##
## Step: AIC=-790.99
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.1 +
## ammonia.pump.flow.2 + Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 +
## Tempered.Water.Temperature.before.Temped.water.cooler + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totalier + spare.dosing.pump.totaliser +
## ammonia.totalier + Methane.totalier + oxygen.totaliser +
## Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - ammonia.pump.flow.1                 1   0.46 1422.8
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.54 1422.9
## - Fermentor.fliud.to.ammonia...OD.meter.L.h               1   0.62 1423.0
## - Station.3.Loop.Temperature          1   0.73 1423.1
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 1   0.95 1423.3
## - total.air.flow                     1   0.96 1423.3
## - pump.inlet                         1   1.12 1423.5
## <none>                               1422.4

```

## - oxygen.flow.stn5	1	1.49	1423.9
## - pressure.at.position.4	1	1.75	1424.1
## - oxygen.totaliser	1	1.87	1424.2
## - CH4.in.offgas..	1	1.90	1424.3
## - Level.on.the.seperator	1	2.22	1424.6
## - Station.5.Loop.Temperature	1	2.41	1424.8
## - oxygen.flow.stn3	1	2.69	1425.1
## - pump.outlet	1	2.78	1425.2
## - vessel	1	3.43	1425.8
## - dissolved.oxygen.at.stn2	1	4.22	1426.6
## - oxygen.flow.stn1	1	4.35	1426.7
## - calcium.chloride.totaliser	1	4.41	1426.8
## - pH.at.stn3	1	4.59	1427.0
## - Cooling.Water.Return.for.Temped.System	1	5.76	1428.1
## - oxygen.flow.stn4	1	6.18	1428.5
## - O2.in.offgas..	1	6.19	1428.6
## - ammonia.totalier	1	7.09	1429.5
## - methane.flow.stn5	1	7.68	1430.0
## - vent.flow	1	9.26	1431.6
## - methane.flow.stn2	1	9.57	1432.0
## - trace.elements.totaliser	1	9.84	1432.2
## - harvest.flow	1	10.20	1432.6
## - Methane.totalier	1	10.47	1432.8
## - EFT..Hours	1	10.92	1433.3
## - oxygen.flow.stn2	1	11.08	1433.5
## - pH.at.stn5	1	12.69	1435.1
## - ammonia.pump.flow.2	1	13.70	1436.1
## - spare.dosing.pump.flow	1	16.05	1438.4
## - dissolved.oxygen.at.stn5	1	16.70	1439.1
## - calcium.chloride.flow	1	16.89	1439.3
## - methane.flow.stn4	1	17.68	1440.0
## - ferrous.sulphate.totaliser	1	19.27	1441.6
## - methane.flow.stn3	1	23.26	1445.6
## - ferrus.sulphate.flow	1	25.89	1448.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.23	1449.6
## - methane.flow.stn1	1	29.42	1451.8
## - magnesium.potassium.totalier	1	34.71	1457.1
## - optical.density	1	55.34	1477.7
## - magnesium.potassium.flow	1	57.66	1480.0
## - phosphoric.acid.flow	1	73.55	1495.9
## - Cooling.loop.B.valve.opening..	1	91.63	1514.0
## - phosphoric.acid.totaliser	1	97.02	1519.4
## - dissolved.oxygen.at.stn3	1	103.40	1525.8
## - trace.elements.flow	1	154.72	1577.1
## - dissolved.oxygen.at.stn4	1	205.64	1628.0
## - spare.dosing.pump.totaliser	1	222.49	1644.9
## - sodium.hydroxide.totaliser	1	876.57	2298.9
##		AIC	
## - ammonia.pump.flow.1	-792.30		
## - Tempered.Water.Temperature.before.Temped.water.cooler	-792.17		
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-792.05		
## - Station.3.Loop.Temperature	-791.88		
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-791.56		
## - total.air.flow	-791.54		

```

## - pump.inlet          -791.30
## <none>                -790.99
## - oxygen.flow.stn5    -790.73
## - pressure.at.position.4 -790.34
## - oxygen.totaliser    -790.16
## - CH4.in.offgas..      -790.11
## - Level.on.the.seperator -789.62
## - Station.5.Loop.Temperature -789.34
## - oxygen.flow.stn3     -788.92
## - pump.outlet          -788.78
## - vessel               -787.80
## - dissolved.oxygen.at.stn2 -786.59
## - oxygen.flow.stn1      -786.39
## - calcium.chloride.totaliser -786.31
## - pH.at.stn3            -786.04
## - Cooling.Water.Return.for.Temped.System -784.27
## - oxygen.flow.stn4      -783.64
## - O2.in.offgas..        -783.62
## - ammonia.totalier      -782.27
## - methane.flow.stn5      -781.36
## - vent.flow              -778.99
## - methane.flow.stn2      -778.51
## - trace.elements.totaliser -778.11
## - harvest.flow           -777.57
## - Methane.totalier       -777.16
## - EFT..Hours             -776.48
## - oxygen.flow.stn2       -776.24
## - pH.at.stn5              -773.82
## - ammonia.pump.flow.2     -772.30
## - spare.dosing.pump.flow -768.78
## - dissolved.oxygen.at.stn5 -767.80
## - calcium.chloride.flow -767.50
## - methane.flow.stn4       -766.33
## - ferrous.sulphate.totaliser -763.94
## - methane.flow.stn3       -757.97
## - ferrus.sulphate.flow     -754.05
## - oxygen..pressure.to.fermentor.loop.mixture -752.05
## - methane.flow.stn1       -748.80
## - magnesium.potassium.totalier -740.94
## - optical.density         -710.58
## - magnesium.potassium.flow -707.20
## - phosphoric.acid.flow     -684.15
## - Cooling.loop.B.valve.opening.. -658.21
## - phosphoric.acid.totaliser -650.54
## - dissolved.oxygen.at.stn3 -641.48
## - trace.elements.flow       -570.07
## - dissolved.oxygen.at.stn4 -501.46
## - spare.dosing.pump.totaliser -479.22
## - sodium.hydroxide.totaliser 243.59
##
## Step: AIC=-792.3
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
##           vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
##           Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +

```

```

##      CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
##      dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
##      methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
##      methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
##      oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
##      oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
##      Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 + Tempered.Water.Temperature.before.Temped.
##      Cooling.Water.Return.for.Temped.System + Cooling.loop.B.valve.opening.. +
##      pump.outlet + pump.inlet + pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
##      phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
##      calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
##      phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
##      trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
##      magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
##      ammonia.totaliser + Methane.totaliser + oxygen.totaliser +
##      Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS
## - Tempered.Water.Temperature.before.Temped.water.cooler 1   0.55 1423.4
## - Fermentor.fliud.to.ammonia...OD.meter.L.h               1   0.58 1423.4
## - Station.3.Loop.Temperature                           1   0.72 1423.5
## - total.air.flow                                     1   0.95 1423.8
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 1   0.97 1423.8
## - pump.inlet                                         1   1.13 1424.0
## <none>                                              1422.8
## - oxygen.flow.stn5                                 1   1.45 1424.3
## - pressure.at.position.4                          1   1.77 1424.6
## - CH4.in.offgas..                                1   1.82 1424.7
## - oxygen.totaliser                            1   1.83 1424.7
## - Level.on.the.seperator                      1   2.18 1425.0
## - Station.5.Loop.Temperature                   1   2.38 1425.2
## - oxygen.flow.stn3                               1   2.57 1425.4
## - pump.outlet                                    1   2.87 1425.7
## - vessel                                         1   3.44 1426.3
## - dissolved.oxygen.at.stn2                     1   4.23 1427.0
## - oxygen.flow.stn1                               1   4.38 1427.2
## - calcium.chloride.totaliser                  1   4.53 1427.4
## - pH.at.stn3                                    1   4.58 1427.4
## - Cooling.Water.Return.for.Temped.System       1   5.76 1428.6
## - O2.in.offgas..                                1   6.28 1429.1
## - oxygen.flow.stn4                               1   6.30 1429.1
## - methane.flow.stn5                            1   7.56 1430.4
## - vent.flow                                      1   9.46 1432.3
## - trace.elements.totaliser                    1   9.90 1432.7
## - methane.flow.stn2                            1   10.07 1432.9
## - harvest.flow                                  1   10.23 1433.0
## - Methane.totalier                            1   10.48 1433.3
## - EFT..Hours                                    1   11.01 1433.8
## - oxygen.flow.stn2                             1   11.44 1434.3
## - pH.at.stn5                                    1   12.67 1435.5
## - spare.dosing.pump.flow                     1   16.15 1439.0
## - dissolved.oxygen.at.stn5                   1   16.60 1439.4
## - calcium.chloride.flow                      1   16.94 1439.8
## - methane.flow.stn4                           1   17.69 1440.5

```

## - ferrous.sulphate.totaliser	1	19.01	1441.8
## - methane.flow.stn3	1	23.11	1445.9
## - ferrus.sulphate.flow	1	25.75	1448.6
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.24	1450.1
## - methane.flow.stn1	1	29.56	1452.4
## - magnesium.potassium.totalier	1	34.41	1457.2
## - optical.density	1	55.06	1477.9
## - magnesium.potassium.flow	1	58.37	1481.2
## - phosphoric.acid.flow	1	73.93	1496.8
## - Cooling.loop.B.valve.opening..	1	91.46	1514.3
## - ammonia.pump.flow.2	1	94.77	1517.6
## - phosphoric.acid.totaliser	1	96.60	1519.4
## - dissolved.oxygen.at.stn3	1	103.85	1526.7
## - trace.elements.flow	1	154.37	1577.2
## - ammonia.totalier	1	174.15	1597.0
## - dissolved.oxygen.at.stn4	1	205.20	1628.0
## - spare.dosing.pump.totaliser	1	222.13	1645.0
## - sodium.hydroxide.totaliser	1	876.17	2299.0
##		AIC	
## - Tempered.Water.Temperature.before.Temped.water.cooler	-793.46		
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-793.43		
## - Station.3.Loop.Temperature	-793.20		
## - total.air.flow	-792.86		
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-792.83		
## - pump.inlet	-792.60		
## <none>	-792.30		
## - oxygen.flow.stn5	-792.10		
## - pressure.at.position.4	-791.62		
## - CH4.in.offgas..	-791.54		
## - oxygen.totaliser	-791.52		
## - Level.on.the.seperator	-790.99		
## - Station.5.Loop.Temperature	-790.69		
## - oxygen.flow.stn3	-790.41		
## - pump.outlet	-789.95		
## - vessel	-789.09		
## - dissolved.oxygen.at.stn2	-787.90		
## - oxygen.flow.stn1	-787.67		
## - calcium.chloride.totaliser	-787.43		
## - pH.at.stn3	-787.37		
## - Cooling.Water.Return.for.Temped.System	-785.58		
## - O2.in.offgas..	-784.80		
## - oxygen.flow.stn4	-784.77		
## - methane.flow.stn5	-782.87		
## - vent.flow	-780.00		
## - trace.elements.totaliser	-779.34		
## - methane.flow.stn2	-779.08		
## - harvest.flow	-778.84		
## - Methane.totalier	-778.46		
## - EFT..Hours	-777.66		
## - oxygen.flow.stn2	-777.01		
## - pH.at.stn5	-775.17		
## - spare.dosing.pump.flow	-769.94		
## - dissolved.oxygen.at.stn5	-769.26		
## - calcium.chloride.flow	-768.75		

```

## - methane.flow.stn4          -767.63
## - ferrous.sulphate.totaliser -765.66
## - methane.flow.stn3          -759.51
## - ferrus.sulphate.flow       -755.59
## - oxygen..pressure.to.fermentor.loop.mixture -753.36
## - methane.flow.stn1          -749.92
## - magnesium.potassium.totalier -742.72
## - optical.density           -712.34
## - magnesium.potassium.flow   -707.50
## - phosphoric.acid.flow       -684.94
## - Cooling.loop.B.valve.opening.. -659.81
## - ammonia.pump.flow.2        -655.09
## - phosphoric.acid.totaliser  -652.49
## - dissolved.oxygen.at.stn3    -642.20
## - trace.elements.flow        -571.92
## - ammonia.totalier           -545.01
## - dissolved.oxygen.at.stn4    -503.44
## - spare.dosing.pump.totaliser -481.11
## - sodium.hydroxide.totaliser 241.64
##
## Step: AIC=-793.46
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
## Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totalier + spare.dosing.pump.totaliser +
## ammonia.totalier + Methane.totalier + oxygen.totaliser +
## Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq   RSS
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117 1  0.42 1423.8
## - Station.3.Loop.Temperature                         1  0.57 1424.0
## - Fermentor.fliud.to.ammonia...OD.meter.L.h            1  0.58 1424.0
## - total.air.flow                                     1  0.93 1424.3
## - pump.inlet                                       1  1.10 1424.5
## <none>                                              1423.4
## - oxygen.flow.stn5                                 1  1.44 1424.8
## - pressure.at.position.4                           1  1.68 1425.1
## - CH4.in.offgas..                                1  1.81 1425.2
## - oxygen.totaliser                               1  1.85 1425.2
## - Level.on.the.seperator                         1  2.24 1425.6
## - oxygen.flow.stn3                                1  2.62 1426.0

```

## - Station.5.Loop.Temperature	1	2.66	1426.0
## - pump.outlet	1	2.90	1426.3
## - vessel	1	3.97	1427.3
## - dissolved.oxygen.at.stn2	1	4.20	1427.6
## - oxygen.flow.stn1	1	4.59	1428.0
## - pH.at.stn3	1	4.62	1428.0
## - calcium.chloride.totaliser	1	4.65	1428.0
## - Cooling.Water.Return.for.Temped.System	1	5.45	1428.8
## - O2.in.offgas..	1	6.24	1429.6
## - oxygen.flow.stn4	1	6.46	1429.8
## - methane.flow.stn5	1	7.46	1430.8
## - vent.flow	1	9.28	1432.7
## - trace.elements.totaliser	1	9.86	1433.2
## - methane.flow.stn2	1	10.06	1433.4
## - harvest.flow	1	10.44	1433.8
## - Methane.totalier	1	10.66	1434.0
## - EFT..Hours	1	11.37	1434.8
## - oxygen.flow.stn2	1	11.45	1434.8
## - pH.at.stn5	1	12.40	1435.8
## - spare.dosing.pump.flow	1	15.97	1439.3
## - dissolved.oxygen.at.stn5	1	16.64	1440.0
## - calcium.chloride.flow	1	16.90	1440.3
## - methane.flow.stn4	1	17.96	1441.3
## - ferrous.sulphate.totaliser	1	19.06	1442.4
## - methane.flow.stn3	1	23.34	1446.7
## - ferrus.sulphate.flow	1	25.94	1449.3
## - oxygen..pressure.to.fermentor.loop.mixture	1	27.96	1451.3
## - methane.flow.stn1	1	29.92	1453.3
## - magnesium.potassium.totalier	1	34.14	1457.5
## - optical.density	1	54.63	1478.0
## - magnesium.potassium.flow	1	58.42	1481.8
## - phosphoric.acid.flow	1	74.04	1497.4
## - Cooling.loop.B.valve.opening..	1	91.01	1514.4
## - ammonia.pump.flow.2	1	95.59	1519.0
## - phosphoric.acid.totaliser	1	96.69	1520.1
## - dissolved.oxygen.at.stn3	1	103.74	1527.1
## - trace.elements.flow	1	154.27	1577.7
## - ammonia.totalier	1	174.20	1597.6
## - dissolved.oxygen.at.stn4	1	205.31	1628.7
## - spare.dosing.pump.totaliser	1	222.07	1645.5
## - sodium.hydroxide.totaliser	1	882.46	2305.8
##		AIC	
## - Cooling.Loop.B.Broth.Return.to.Fermenter.mixer.J1117	-794.82		
## - Station.3.Loop.Temperature	-794.60		
## - Fermentor.fliud.to.ammonia...OD.meter.L.h	-794.58		
## - total.air.flow	-794.05		
## - pump.inlet	-793.80		
## <none>	-793.46		
## - oxygen.flow.stn5	-793.29		
## - pressure.at.position.4	-792.92		
## - CH4.in.offgas..	-792.72		
## - oxygen.totaliser	-792.67		
## - Level.on.the.seperator	-792.07		
## - oxygen.flow.stn3	-791.49		

```

## - Station.5.Loop.Temperature           -791.43
## - pump.outlet                         -791.08
## - vessel                             -789.45
## - dissolved.oxygen.at.stn2          -789.10
## - oxygen.flow.stn1                   -788.51
## - pH.at.stn3                          -788.47
## - calcium.chloride.totaliser        -788.43
## - Cooling.Water.Return.for.Temped.System -787.22
## - O2.in.offgas..                     -786.02
## - oxygen.flow.stn4                   -785.69
## - methane.flow.stn5                 -784.18
## - vent.flow                           -781.44
## - trace.elements.totaliser          -780.56
## - methane.flow.stn2                 -780.27
## - harvest.flow                        -779.68
## - Methane.totalier                  -779.36
## - EFT..Hours                         -778.29
## - oxygen.flow.stn2                   -778.17
## - pH.at.stn5                          -776.74
## - spare.dosing.pump.flow            -771.38
## - dissolved.oxygen.at.stn5          -770.37
## - calcium.chloride.flow             -769.98
## - methane.flow.stn4                 -768.39
## - ferrous.sulphate.totaliser       -766.74
## - methane.flow.stn3                 -760.34
## - ferrus.sulphate.flow              -756.47
## - oxygen..pressure.to.fermentor.loop.mixture -753.47
## - methane.flow.stn1                 -750.55
## - magnesium.potassium.totalier     -744.30
## - optical.density                  -714.14
## - magnesium.potassium.flow         -708.62
## - phosphoric.acid.flow             -685.99
## - Cooling.loop.B.valve.opening..   -661.65
## - ammonia.pump.flow.2              -655.14
## - phosphoric.acid.totaliser       -653.58
## - dissolved.oxygen.at.stn3         -643.58
## - trace.elements.flow              -573.30
## - ammonia.totalier                 -546.20
## - dissolved.oxygen.at.stn4         -504.56
## - spare.dosing.pump.totaliser     -482.45
## - sodium.hydroxide.totaliser      246.06
##
## Step: AIC=-794.82
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
##   vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
##   Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
##   CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
##   dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
##   methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
##   methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
##   oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
##   oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
##   Cooling.Water.Return.for.Temped.System + Cooling.loop.B.valve.opening.. +
##   pump.outlet + pump.inlet + pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +

```

```

## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
## ammonia.totaliser + Methane.totaliser + oxygen.totaliser +
## Fermentor.fliud.to.ammonia...OD.meter.L.h
##
##                                     Df Sum of Sq    RSS     AIC
## - Fermentor.fliud.to.ammonia...OD.meter.L.h  1   0.62 1424.4 -795.88
## - Station.3.Loop.Temperature                 1   0.71 1424.5 -795.74
## - total.air.flow                           1   0.88 1424.7 -795.49
## - pump.inlet                                1   1.04 1424.8 -795.25
## <none>                                         1423.8 -794.82
## - oxygen.flow.stn5                          1   1.43 1425.2 -794.65
## - pressure.at.position.4                  1   1.63 1425.4 -794.35
## - oxygen.totaliser                         1   1.79 1425.6 -794.11
## - CH4.in.offgas..                          1   1.86 1425.7 -794.00
## - Level.on.the.seperator                  1   2.29 1426.1 -793.34
## - Station.5.Loop.Temperature               1   2.38 1426.2 -793.21
## - pump.outlet                             1   2.75 1426.5 -792.66
## - oxygen.flow.stn3                          1   2.80 1426.6 -792.58
## - vessel                                    1   3.76 1427.6 -791.13
## - dissolved.oxygen.at.stn2                1   3.99 1427.8 -790.77
## - oxygen.flow.stn1                          1   4.39 1428.2 -790.17
## - calcium.chloride.totaliser              1   4.51 1428.3 -790.00
## - pH.at.stn3                               1   4.64 1428.4 -789.80
## - O2.in.offgas..                           1   6.23 1430.0 -787.40
## - oxygen.flow.stn4                          1   6.31 1430.1 -787.27
## - methane.flow.stn5                        1   7.55 1431.3 -785.40
## - Cooling.Water.Return.for.Temped.System  1   8.85 1432.7 -783.44
## - vent.flow                                 1   9.38 1433.2 -782.64
## - trace.elements.totaliser                 1   9.74 1433.5 -782.11
## - methane.flow.stn2                        1   10.11 1433.9 -781.54
## - Methane.totalier                         1   10.33 1434.1 -781.21
## - harvest.flow                            1   10.40 1434.2 -781.11
## - EFT..Hours                               1   11.27 1435.1 -779.80
## - oxygen.flow.stn2                         1   11.48 1435.3 -779.49
## - pH.at.stn5                               1   12.55 1436.3 -777.88
## - spare.dosing.pump.flow                  1   15.86 1439.7 -772.91
## - dissolved.oxygen.at.stn5                1   16.87 1440.7 -771.39
## - calcium.chloride.flow                   1   16.96 1440.8 -771.25
## - methane.flow.stn4                        1   17.89 1441.7 -769.87
## - ferrous.sulphate.totaliser              1   19.29 1443.1 -767.76
## - methane.flow.stn3                        1   23.78 1447.6 -761.06
## - ferrus.sulphate.flow                    1   26.04 1449.8 -757.70
## - oxygen..pressure.to.fermentor.loop.mixture 1   27.88 1451.7 -754.96
## - methane.flow.stn1                        1   29.55 1453.3 -752.47
## - magnesium.potassium.totalier            1   34.25 1458.0 -745.50
## - optical.density                         1   54.54 1478.3 -715.66
## - magnesium.potassium.flow                1   58.55 1482.4 -709.81
## - phosphoric.acid.flow                   1   74.55 1498.3 -686.64
## - Cooling.loop.B.valve.opening..          1   91.33 1515.1 -662.59
## - ammonia.pump.flow.2                     1   95.33 1519.1 -656.89

```

```

## - phosphoric.acid.totaliser          1    97.18 1521.0 -654.28
## - dissolved.oxygen.at.stn3          1   103.31 1527.1 -645.58
## - trace.elements.flow               1   155.78 1579.6 -572.66
## - ammonia.totalier                 1   173.99 1597.8 -547.90
## - dissolved.oxygen.at.stn4          1   204.99 1628.8 -506.42
## - spare.dosing.pump.totaliser      1   221.83 1645.6 -484.21
## - sodium.hydroxide.totaliser       1   885.56 2309.4  247.36
##
## Step: AIC=-795.88
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.3.Loop.Temperature + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
## Cooling.Water.Return.for.Temped.System + Cooling.loop.B.valve.opening.. +
## pump.outlet + pump.inlet + pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
## ammonia.totalier + Methane.totalier + oxygen.totaliser
##
##                                     Df Sum of Sq   RSS     AIC
## - Station.3.Loop.Temperature      1   0.68 1425.1 -796.85
## - total.air.flow                  1   0.84 1425.3 -796.60
## - pump.inlet                      1   0.99 1425.4 -796.38
## <none>                           1424.4 -795.88
## - oxygen.flow.stn5                1   1.36 1425.8 -795.82
## - pressure.at.position.4          1   1.44 1425.9 -795.70
## - oxygen.totaliser                1   1.77 1426.2 -795.20
## - CH4.in.offgas..                 1   2.14 1426.6 -794.63
## - Station.5.Loop.Temperature      1   2.41 1426.8 -794.22
## - Level.on.the.seperator          1   2.54 1427.0 -794.03
## - pump.outlet                     1   2.60 1427.0 -793.94
## - oxygen.flow.stn3                1   2.67 1427.1 -793.84
## - vessel                          1   3.78 1428.2 -792.16
## - dissolved.oxygen.at.stn2        1   3.98 1428.4 -791.85
## - oxygen.flow.stn1                1   4.70 1429.1 -790.77
## - pH.at.stn3                      1   4.79 1429.2 -790.63
## - calcium.chloride.totaliser      1   4.96 1429.4 -790.38
## - oxygen.flow.stn4                1   6.36 1430.8 -788.26
## - O2.in.offgas..                  1   6.59 1431.0 -787.91
## - methane.flow.stn5               1   7.24 1431.7 -786.93
## - Cooling.Water.Return.for.Temped.System 1   8.68 1433.1 -784.77
## - vent.flow                        1   8.97 1433.4 -784.33
## - Methane.totalier                 1   10.09 1434.5 -782.64
## - trace.elements.totaliser         1   10.15 1434.6 -782.55
## - methane.flow.stn2               1   10.26 1434.7 -782.39
## - harvest.flow                     1   10.47 1434.9 -782.07

```

```

## - oxygen.flow.stn2
## - pH.at.stn5
## - EFT..Hours
## - spare.dosing.pump.flow
## - dissolved.oxygen.at.stn5
## - calcium.chloride.flow
## - methane.flow.stn4
## - ferrous.sulphate.totaliser
## - methane.flow.stn3
## - ferrus.sulphate.flow
## - oxygen..pressure.to.fermentor.loop.mixture
## - methane.flow.stn1
## - magnesium.potassium.totalier
## - optical.density
## - magnesium.potassium.flow
## - phosphoric.acid.flow
## - Cooling.loop.B.valve.opening..
## - ammonia.pump.flow.2
## - phosphoric.acid.totaliser
## - dissolved.oxygen.at.stn3
## - trace.elements.flow
## - ammonia.totalier
## - dissolved.oxygen.at.stn4
## - spare.dosing.pump.totaliser
## - sodium.hydroxide.totaliser
##
## Step: AIC=-796.85
## interpolated_acetic ~ EFT..Hours + total.air.flow + vent.flow +
## vessel + Station.5.Loop.Temperature + Level.on.the.seperator +
## harvest.flow + pH.at.stn5 + pH.at.stn3 + CH4.in.offgas.. +
## O2.in.offgas.. + dissolved.oxygen.at.stn2 + dissolved.oxygen.at.stn3 +
## dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 + methane.flow.stn1 +
## methane.flow.stn2 + methane.flow.stn3 + methane.flow.stn4 +
## methane.flow.stn5 + oxygen.flow.stn1 + oxygen.flow.stn2 +
## oxygen.flow.stn3 + oxygen.flow.stn4 + oxygen.flow.stn5 +
## optical.density + ammonia.pump.flow.2 + Cooling.Water.Return.for.Temped.System +
## Cooling.loop.B.valve.opening.. + pump.outlet + pump.inlet +
## pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totalier + spare.dosing.pump.totaliser +
## ammonia.totalier + Methane.totalier + oxygen.totaliser
##
##                                     Df Sum of Sq    RSS     AIC
## - total.air.flow                 1   0.85 1426.0 -797.56
## - pump.inlet                     1   1.01 1426.1 -797.32
## - oxygen.flow.stn5               1   1.31 1426.4 -796.86
## <none>                           1425.1 -796.85
## - pressure.at.position.4        1   1.39 1426.5 -796.74
## - Station.5.Loop.Temperature   1   1.75 1426.8 -796.20
## - oxygen.totaliser              1   1.78 1426.9 -796.15
## - CH4.in.offgas..                1   2.13 1427.2 -795.63

```

```

## - Level.on.the.seperator          1    2.64 1427.7 -794.85
## - oxygen.flow.stn3              1    2.70 1427.8 -794.76
## - pump.outlet                   1    2.70 1427.8 -794.75
## - vessel                        1    3.10 1428.2 -794.16
## - dissolved.oxygen.at.stn2      1    4.01 1429.1 -792.78
## - oxygen.flow.stn1              1    4.77 1429.9 -791.63
## - pH.at.stn3                   1    4.77 1429.9 -791.63
## - calcium.chloride.totaliser   1    4.80 1429.9 -791.59
## - oxygen.flow.stn4              1    6.28 1431.4 -789.35
## - O2.in.offgas..                1    6.47 1431.6 -789.06
## - methane.flow.stn5             1    7.15 1432.2 -788.04
## - Cooling.Water.Return.for.Temped.System 1    8.67 1433.8 -785.75
## - vent.flow                     1    9.02 1434.1 -785.22
## - trace.elements.totaliser     1    9.83 1434.9 -784.00
## - Methane.totalier             1    10.16 1435.3 -783.50
## - harvest.flow                 1    10.34 1435.5 -783.23
## - methane.flow.stn2            1    10.40 1435.5 -783.14
## - oxygen.flow.stn2              1    11.68 1436.8 -781.23
## - pH.at.stn5                  1    12.33 1437.4 -780.25
## - EFT..Hours                   1    14.48 1439.6 -777.02
## - spare.dosing.pump.flow      1    16.05 1441.2 -774.67
## - dissolved.oxygen.at.stn5     1    16.93 1442.0 -773.35
## - calcium.chloride.flow       1    17.68 1442.8 -772.23
## - methane.flow.stn4            1    17.81 1442.9 -772.03
## - ferrous.sulphate.totaliser  1    18.77 1443.9 -770.60
## - methane.flow.stn3            1    23.64 1448.8 -763.32
## - ferrus.sulphate.flow        1    26.27 1451.4 -759.41
## - oxygen..pressure.to.fermentor.loop.mixture 1    27.82 1452.9 -757.11
## - methane.flow.stn1            1    31.06 1456.2 -752.29
## - magnesium.potassium.totalier 1    34.20 1459.3 -747.64
## - optical.density             1    53.97 1479.1 -718.59
## - magnesium.potassium.flow   1    61.60 1486.7 -707.48
## - phosphoric.acid.flow       1    75.05 1500.2 -688.05
## - ammonia.pump.flow.2         1    94.91 1520.0 -659.64
## - Cooling.loop.B.valve.opening.. 1    94.91 1520.0 -659.64
## - phosphoric.acid.totaliser  1    97.60 1522.7 -655.83
## - dissolved.oxygen.at.stn3     1    104.10 1529.2 -646.64
## - trace.elements.flow          1    155.47 1580.6 -575.30
## - ammonia.totalier            1    173.97 1599.1 -550.18
## - dissolved.oxygen.at.stn4     1    206.27 1631.4 -507.00
## - spare.dosing.pump.totaliser 1    225.56 1650.7 -481.61
## - sodium.hydroxide.totaliser  1    913.80 2338.9  270.80
##
## Step: AIC=-797.56
## interpolated_acetic ~ EFT..Hours + vent.flow + vessel + Station.5.Loop.Temperature +
##   Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
##   CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
##   dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
##   methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
##   methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
##   oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
##   oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
##   Cooling.Water.Return.for.Temped.System + Cooling.loop.B.valve.opening.. +
##   pump.outlet + pump.inlet + pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +

```

```

## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
## ammonia.totaliser + Methane.totaliser + oxygen.totaliser
##
##                                     Df Sum of Sq   RSS      AIC
## - pump.inlet                      1  0.42 1426.4 -798.93
## - pressure.at.position.4          1  1.19 1427.2 -797.75
## <none>                           1426.0 -797.56
## - oxygen.flow.stn5                1  1.52 1427.5 -797.26
## - Station.5.Loop.Temperature     1  1.72 1427.7 -796.95
## - oxygen.totaliser               1  1.77 1427.7 -796.87
## - CH4.in.offgas..                 1  2.05 1428.0 -796.45
## - Level.on.the.seperator        1  2.56 1428.5 -795.69
## - oxygen.flow.stn3                1  2.74 1428.7 -795.42
## - pump.outlet                     1  2.96 1428.9 -795.08
## - vessel                          1  3.10 1429.0 -794.88
## - dissolved.oxygen.at.stn2       1  3.95 1429.9 -793.59
## - oxygen.flow.stn1                1  4.56 1430.5 -792.66
## - pH.at.stn3                     1  4.63 1430.6 -792.57
## - calcium.chloride.totaliser    1  4.72 1430.7 -792.43
## - oxygen.flow.stn4                1  6.23 1432.2 -790.14
## - O2.in.offgas..                  1  6.35 1432.3 -789.97
## - methane.flow.stn5              1  7.79 1433.7 -787.80
## - Cooling.Water.Return.for.Temped.System 1  9.13 1435.1 -785.78
## - trace.elements.totaliser       1  9.90 1435.8 -784.62
## - Methane.totalier               1 10.02 1436.0 -784.44
## - methane.flow.stn2              1 10.18 1436.1 -784.20
## - harvest.flow                   1 10.28 1436.2 -784.05
## - oxygen.flow.stn2                1 11.49 1437.4 -782.24
## - pH.at.stn5                     1 12.22 1438.2 -781.14
## - EFT..Hours                     1 14.12 1440.1 -778.29
## - spare.dosing.pump.flow        1 16.00 1442.0 -775.47
## - dissolved.oxygen.at.stn5      1 16.86 1442.8 -774.18
## - calcium.chloride.flow         1 17.15 1443.1 -773.75
## - methane.flow.stn4              1 17.61 1443.6 -773.06
## - ferrous.sulphate.totaliser    1 18.71 1444.7 -771.41
## - methane.flow.stn3              1 23.71 1449.7 -763.96
## - vent.flow                      1 23.76 1449.7 -763.88
## - ferrus.sulphate.flow           1 26.90 1452.9 -759.20
## - oxygen..pressure.to.fermentor.loop.mixture 1 27.81 1453.8 -757.86
## - methane.flow.stn1              1 30.43 1456.4 -753.97
## - magnesium.potassium.totalier  1 35.28 1461.2 -746.80
## - optical.density               1 53.86 1479.8 -719.51
## - magnesium.potassium.flow      1 61.33 1487.3 -708.64
## - phosphoric.acid.flow          1 74.36 1500.3 -689.81
## - ammonia.pump.flow.2            1 94.30 1520.3 -661.30
## - Cooling.loop.B.valve.opening.. 1 94.49 1520.4 -661.04
## - phosphoric.acid.totaliser     1 98.63 1524.6 -655.16
## - dissolved.oxygen.at.stn3      1 103.83 1529.8 -647.81
## - trace.elements.flow            1 159.10 1585.1 -571.18
## - ammonia.totalier               1 173.42 1599.4 -551.77

```

```

## - dissolved.oxygen.at.stn4 1 207.31 1633.3 -506.50
## - spare.dosing.pump.totaliser 1 227.40 1653.4 -480.10
## - sodium.hydroxide.totaliser 1 917.43 2343.4 272.94
##
## Step: AIC=-798.93
## interpolated_acetic ~ EFT..Hours + vent.flow + vessel + Station.5.Loop.Temperature +
## Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
## CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
## dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
## methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
## methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
## oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
## oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
## Cooling.Water.Return.for.Temped.System + Cooling.loop.B.valve.opening.. +
## pump.outlet + pressure.at.position.4 + oxygen..pressure.to.fermentor.loop.mixture +
## phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
## calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
## phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
## trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
## magnesium.potassium.totaliser + spare.dosing.pump.totaliser +
## ammonia.totaliser + Methane.totaliser + oxygen.totaliser
##
##                                     Df Sum of Sq   RSS   AIC
## - pressure.at.position.4 1  1.23 1427.6 -799.06
## <none>                      1426.4 -798.93
## - oxygen.flow.stn5 1  1.58 1428.0 -798.53
## - Station.5.Loop.Temperature 1  1.69 1428.1 -798.38
## - oxygen.totaliser 1  1.76 1428.1 -798.26
## - CH4.in.offgas.. 1  2.09 1428.5 -797.77
## - Level.on.the.seperator 1  2.64 1429.0 -796.94
## - oxygen.flow.stn3 1  2.71 1429.1 -796.83
## - vessel 1  3.13 1429.5 -796.20
## - pump.outlet 1  3.28 1429.7 -795.97
## - dissolved.oxygen.at.stn2 1  3.93 1430.3 -794.99
## - oxygen.flow.stn1 1  4.55 1430.9 -794.05
## - calcium.chloride.totaliser 1  4.71 1431.1 -793.81
## - pH.at.stn3 1  4.73 1431.1 -793.77
## - oxygen.flow.stn4 1  6.23 1432.6 -791.52
## - O2.in.offgas.. 1  6.33 1432.7 -791.36
## - methane.flow.stn5 1  7.88 1434.2 -789.03
## - Cooling.Water.Return.for.Temped.System 1  9.19 1435.6 -787.07
## - trace.elements.totaliser 1  9.85 1436.2 -786.06
## - methane.flow.stn2 1  9.95 1436.3 -785.92
## - Methane.totalier 1  9.97 1436.3 -785.89
## - harvest.flow 1  10.31 1436.7 -785.38
## - oxygen.flow.stn2 1  11.26 1437.6 -783.95
## - pH.at.stn5 1  12.15 1438.5 -782.61
## - EFT..Hours 1  14.12 1440.5 -779.66
## - spare.dosing.pump.flow 1  15.92 1442.3 -776.97
## - dissolved.oxygen.at.stn5 1  16.78 1443.2 -775.67
## - calcium.chloride.flow 1  17.23 1443.6 -775.01
## - methane.flow.stn4 1  17.59 1444.0 -774.46
## - ferrous.sulphate.totaliser 1  18.74 1445.1 -772.75
## - methane.flow.stn3 1  23.68 1450.0 -765.38

```

```

## - vent.flow
## - ferrus.sulphate.flow
## - oxygen..pressure.to.fermentor.loop.mixture
## - methane.flow.stn1
## - magnesium.potassium.totalier
## - optical.density
## - magnesium.potassium.flow
## - phosphoric.acid.flow
## - Cooling.loop.B.valve.opening..
## - ammonia.pump.flow.2
## - phosphoric.acid.totaliser
## - dissolved.oxygen.at.stn3
## - trace.elements.flow
## - ammonia.totalier
## - dissolved.oxygen.at.stn4
## - spare.dosing.pump.totaliser
## - sodium.hydroxide.totaliser
##
## Step: AIC=-799.06
## interpolated_acetic ~ EFT..Hours + vent.flow + vessel + Station.5.Loop.Temperature +
##     Level.on.the.seperator + harvest.flow + pH.at.stn5 + pH.at.stn3 +
##     CH4.in.offgas.. + O2.in.offgas.. + dissolved.oxygen.at.stn2 +
##     dissolved.oxygen.at.stn3 + dissolved.oxygen.at.stn4 + dissolved.oxygen.at.stn5 +
##     methane.flow.stn1 + methane.flow.stn2 + methane.flow.stn3 +
##     methane.flow.stn4 + methane.flow.stn5 + oxygen.flow.stn1 +
##     oxygen.flow.stn2 + oxygen.flow.stn3 + oxygen.flow.stn4 +
##     oxygen.flow.stn5 + optical.density + ammonia.pump.flow.2 +
##     Cooling.Water.Return.for.Temped.System + Cooling.loop.B.valve.opening.. +
##     pump.outlet + oxygen..pressure.to.fermentor.loop.mixture +
##     phosphoric.acid.flow + trace.elements.flow + ferrus.sulphate.flow +
##     calcium.chloride.flow + magnesium.potassium.flow + spare.dosing.pump.flow +
##     phosphoric.acid.totaliser + sodium.hydroxide.totaliser +
##     trace.elements.totaliser + ferrous.sulphate.totaliser + calcium.chloride.totaliser +
##     magnesium.potassium.totalier + spare.dosing.pump.totaliser +
##     ammonia.totalier + Methane.totalier + oxygen.totaliser
##
##                                     Df Sum of Sq    RSS      AIC
## <none>                         1427.6 -799.06
## - oxygen.flow.stn5                1     1.43 1429.0 -798.91
## - Station.5.Loop.Temperature      1     1.66 1429.3 -798.55
## - oxygen.totaliser                1     1.88 1429.5 -798.23
## - CH4.in.offgas..                 1     2.02 1429.6 -798.01
## - Level.on.the.seperator         1     2.72 1430.3 -796.95
## - oxygen.flow.stn3                1     2.89 1430.5 -796.69
## - vessel                          1     3.11 1430.7 -796.37
## - pump.outlet                     1     3.85 1431.5 -795.26
## - dissolved.oxygen.at.stn2       1     3.86 1431.5 -795.23
## - oxygen.flow.stn1                1     4.35 1432.0 -794.50
## - calcium.chloride.totaliser      1     4.47 1432.1 -794.31
## - pH.at.stn3                      1     4.57 1432.2 -794.16
## - oxygen.flow.stn4                1     6.05 1433.7 -791.93
## - O2.in.offgas..                  1     6.33 1433.9 -791.51
## - methane.flow.stn5                1     7.67 1435.3 -789.50
## - trace.elements.totaliser        1     9.69 1437.3 -786.45

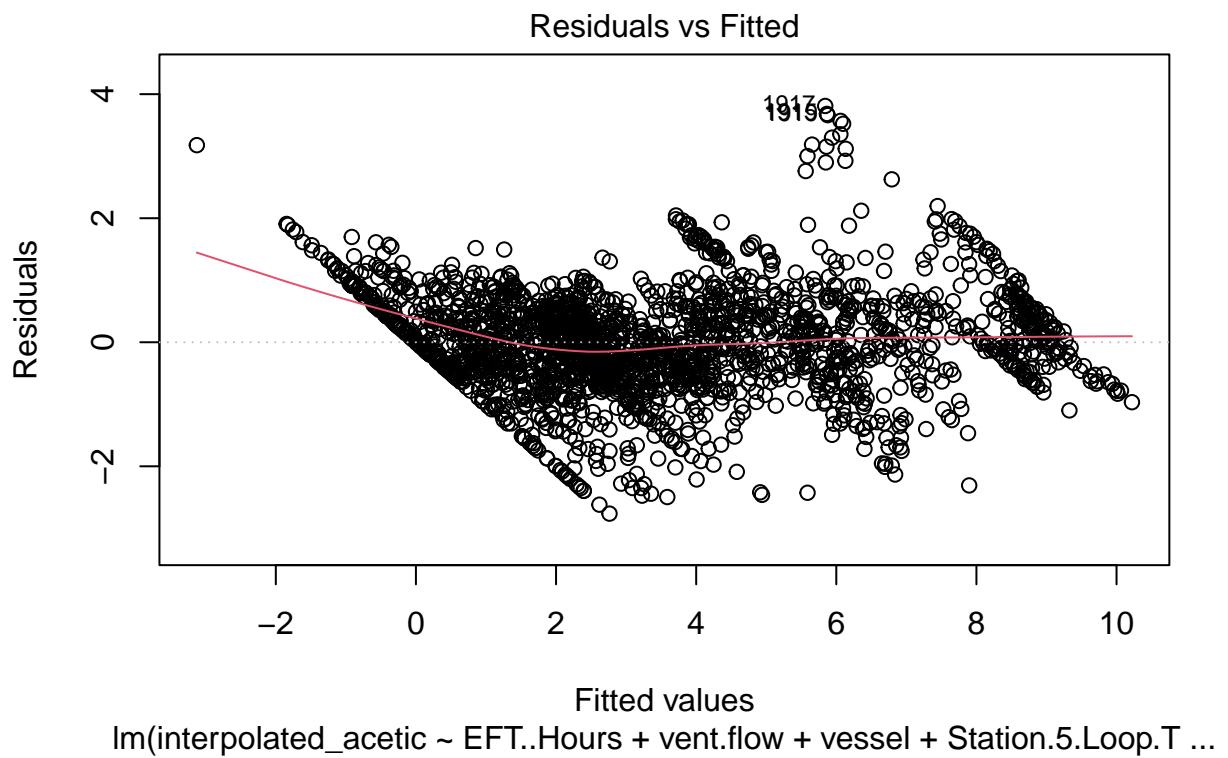
```

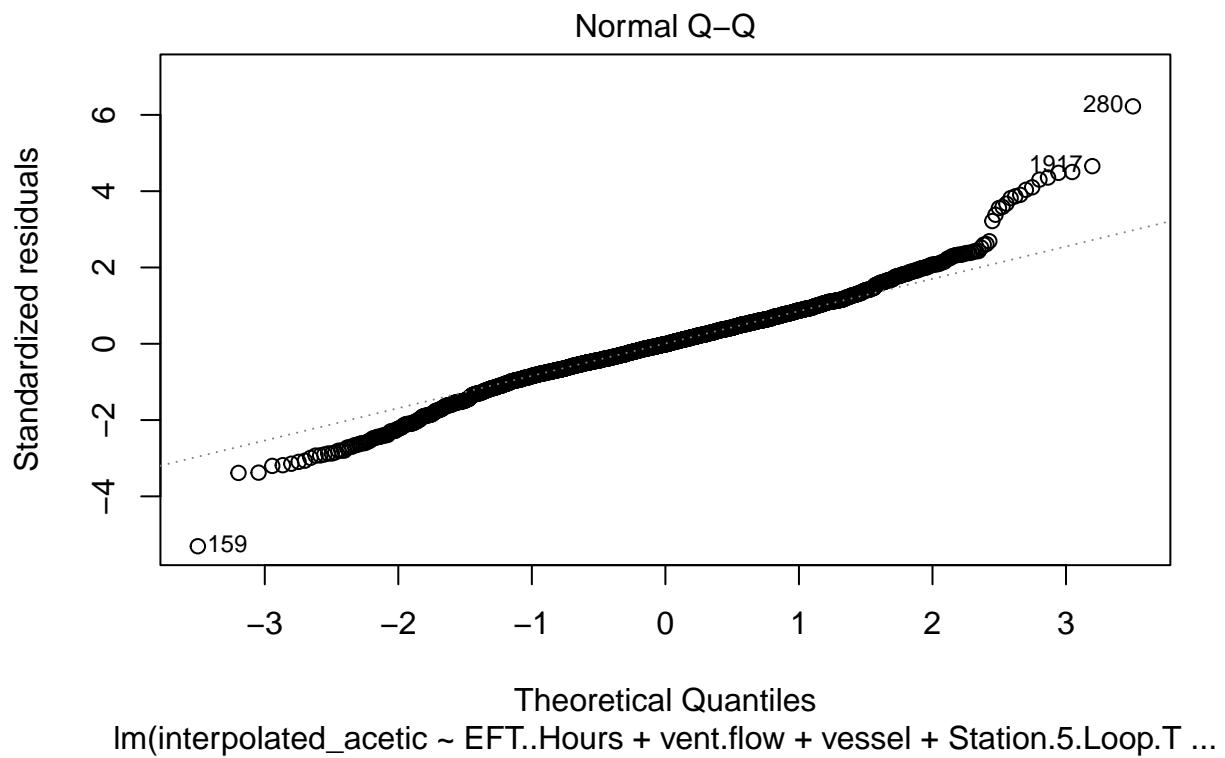
```

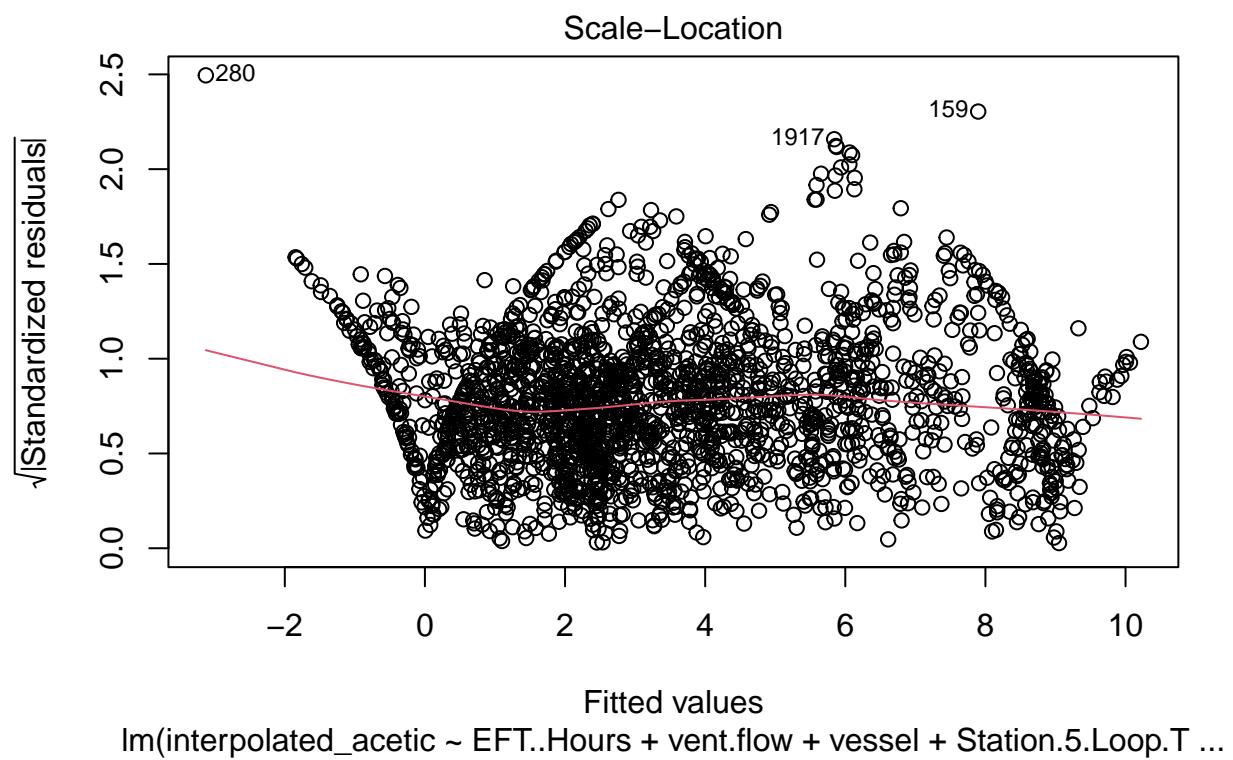
## - methane.flow.stn2          1    9.87 1437.5 -786.19
## - Methane.totalier           1   10.02 1437.6 -785.97
## - Cooling.Water.Return.for.Temped.System 1   10.10 1437.7 -785.84
## - harvest.flow                1   10.53 1438.1 -785.20
## - oxygen.flow.stn2            1   11.34 1438.9 -783.99
## - pH.at.stn5                 1   11.97 1439.6 -783.03
## - EFT..Hours                  1   13.81 1441.4 -780.28
## - spare.dosing.pump.flow     1   15.83 1443.4 -777.26
## - calcium.chloride.flow      1   17.28 1444.9 -775.08
## - methane.flow.stn4            1   17.38 1445.0 -774.94
## - ferrous.sulphate.totaliser 1   18.67 1446.3 -773.01
## - dissolved.oxygen.at.stn5   1   22.53 1450.1 -767.26
## - vent.flow                   1   22.91 1450.5 -766.69
## - methane.flow.stn3            1   23.93 1451.5 -765.17
## - oxygen..pressure.to.fermentor.loop.mixture 1   27.70 1455.3 -759.57
## - ferrus.sulphate.flow        1   27.91 1455.5 -759.26
## - methane.flow.stn1            1   29.83 1457.4 -756.41
## - magnesium.potassium.totalier 1   35.65 1463.3 -747.81
## - optical.density             1   54.68 1482.3 -719.91
## - magnesium.potassium.flow    1   62.00 1489.6 -709.28
## - phosphoric.acid.flow        1   73.99 1501.6 -691.96
## - Cooling.loop.B.valve.opening.. 1   93.23 1520.8 -664.48
## - ammonia.pump.flow.2         1   95.05 1522.7 -661.90
## - phosphoric.acid.totaliser   1   99.07 1526.7 -656.21
## - dissolved.oxygen.at.stn3    1  104.56 1532.2 -648.46
## - trace.elements.flow          1  162.41 1590.0 -568.44
## - ammonia.totalier            1  174.99 1602.6 -551.42
## - dissolved.oxygen.at.stn4    1  217.89 1645.5 -494.39
## - spare.dosing.pump.totaliser 1  227.83 1655.4 -481.39
## - sodium.hydroxide.totaliser 1  933.03 2360.6  284.77

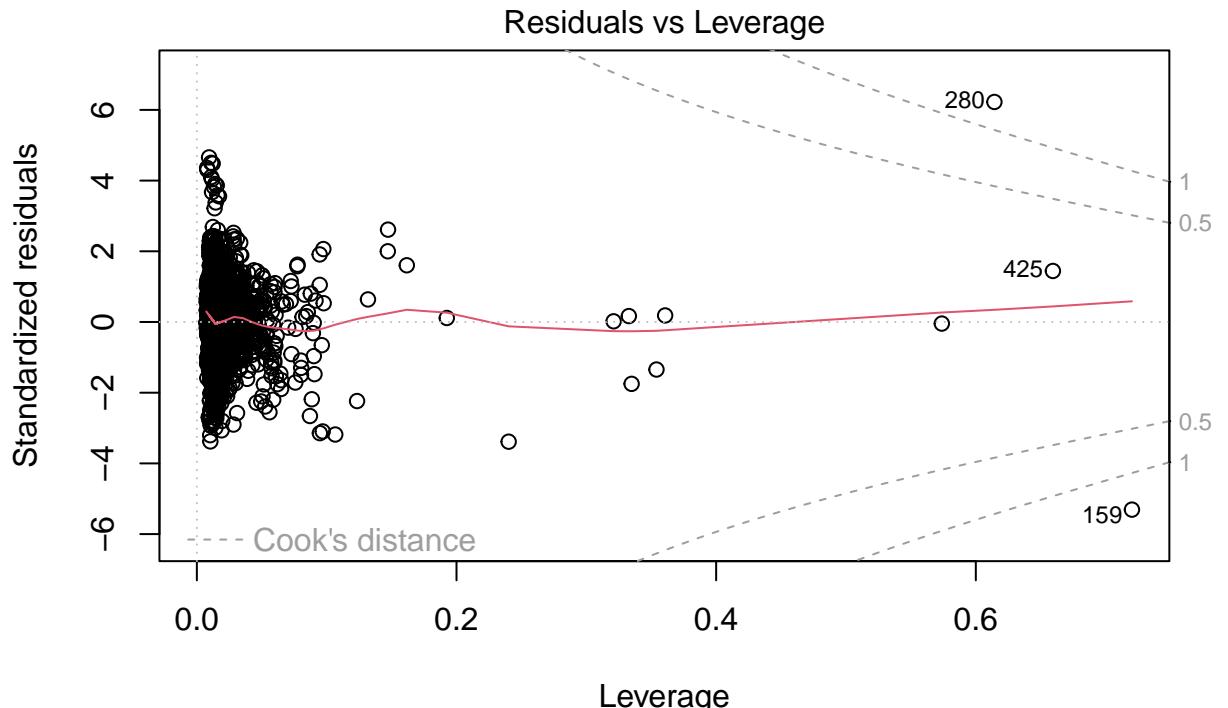
plot(lmstep)

```





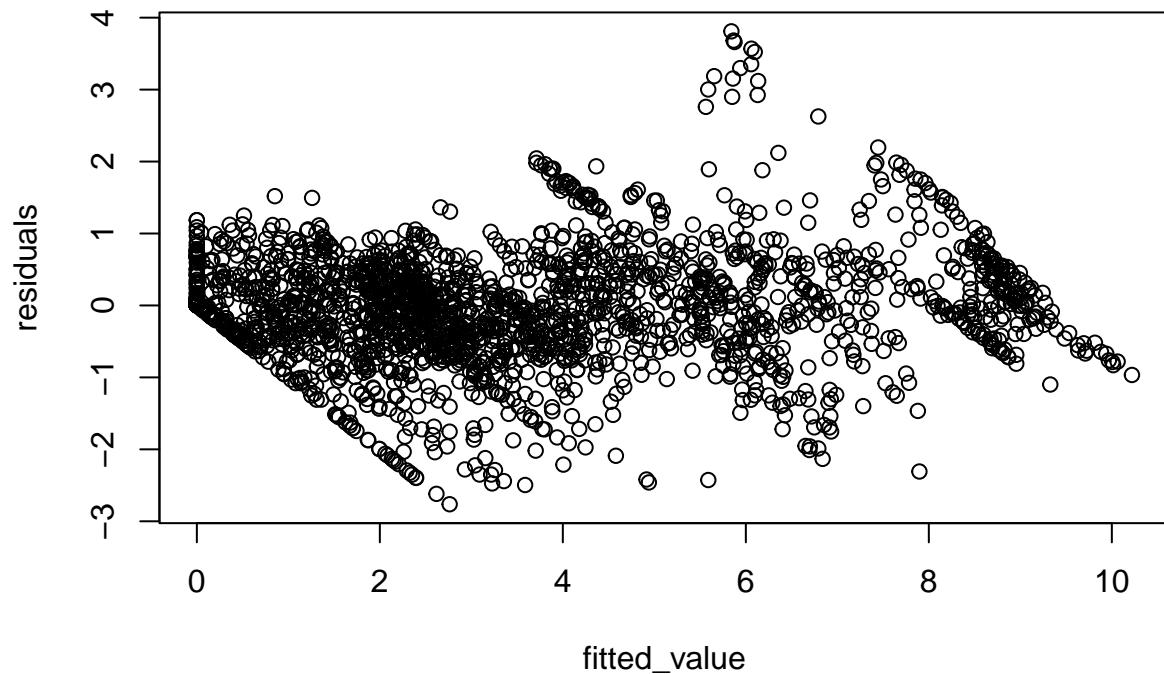




```
pred_step = predict(lmstep , data1 )
pred_step[ which(pred_step<0) ] = 0
```

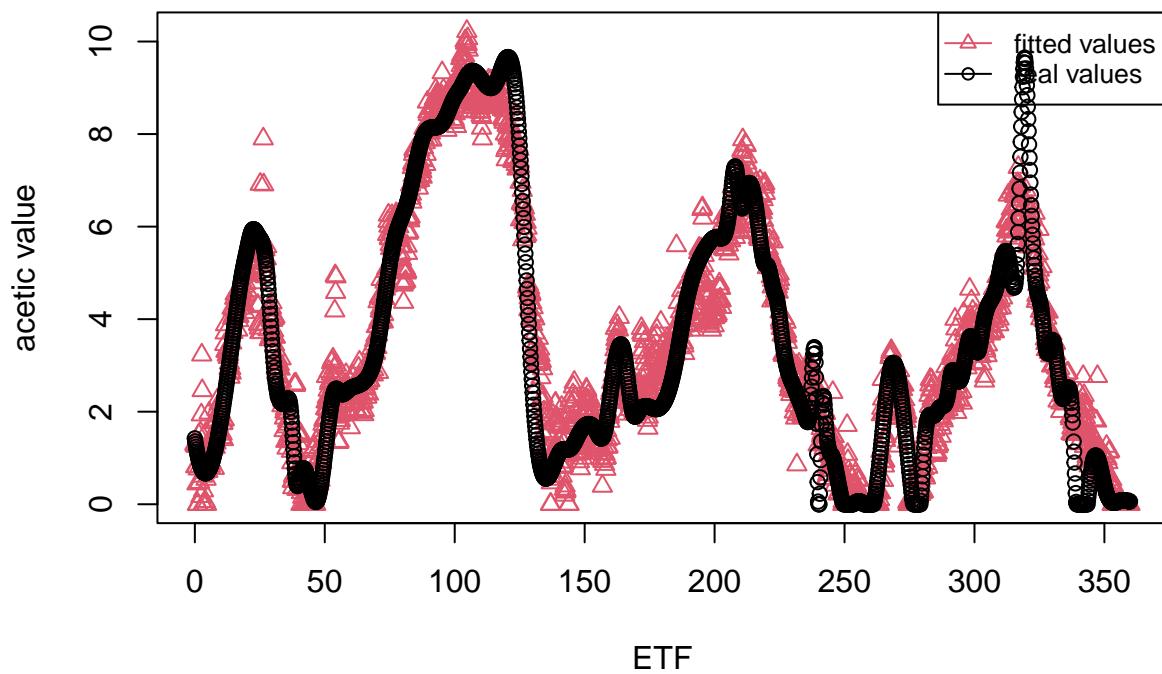
```
plot(pred_step, (data1[,68] - pred_step) , xlab = 'fitted_value' , ylab = 'residuals', main = 'residuals vs fitted values')
```

residual plot with correction



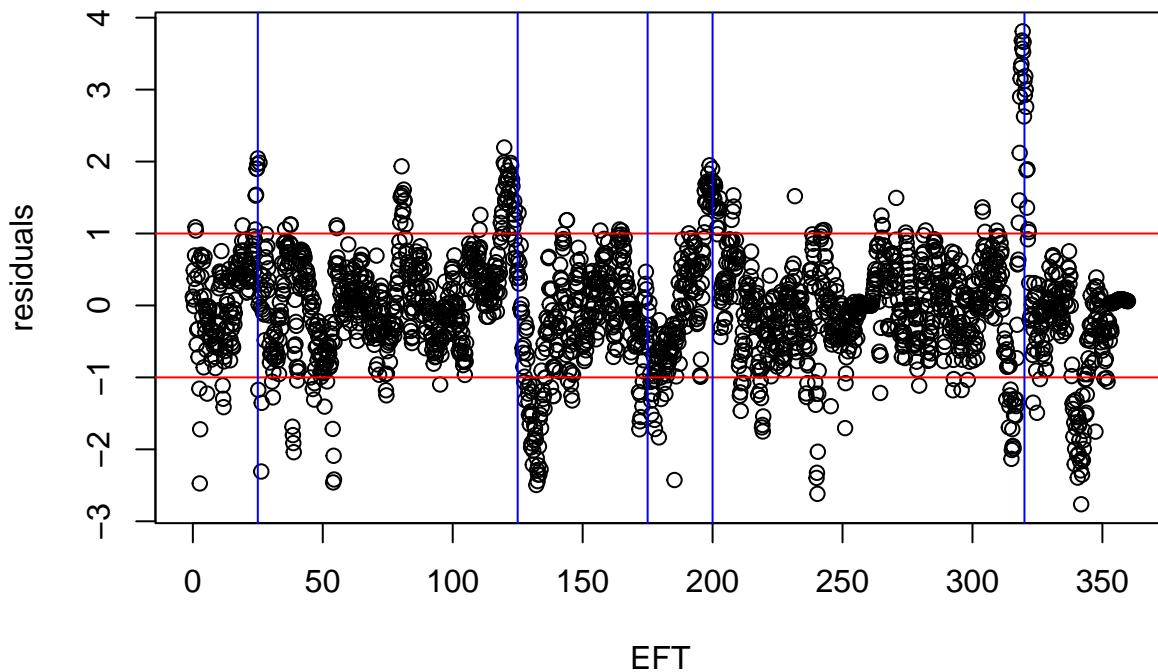
```
plot(data1$EFT..Hours , pred_step , xlab='ETF',ylab='acetic value' , col = 2 , pch = 2 , main = 'with s  
points(data1$EFT..Hours , data1$interpolated_acetic , type='p' , col = 1 , pch = 1)  
legend("topright", cex = 0.8, c('fitted values',"real values"),lty=c(1, 1), pch=c(2, 1), col=c(2, 1))
```

with step_wise model



```
plot(data1$EFT..Hours , (data1[,68] - pred_step ) , xlab = 'EFT' , ylab = 'residuals' , main ='residuals')
abline(h = c(1,-1) , col = 'red')
abline(v = c(25,125,175,200,320) , col = 'blue')
```

residuals VS EFT



```
cat('for step-lm, R-squared is: ', summary(lmstep)$r.squared)
```

```
## for step-lm, R-squared is: 0.9100984
```

```
Mean_Error_step = mean( abs( pred_step - data1$interpolated_acetic) )
cat('mean absolute error of step-lm: ', Mean_Error_step)
```

```
## mean absolute error of step-lm: 0.5737666
```

```
cat('mean absolute error of refitted-lasso: ', Mean_Error_lasso)
```

```
## mean absolute error of refitted-lasso: 1.140247
```

Box-cox

```
library(MASS)
epsilon = 1e-4
boxData1 = data1[ , c(index - 1,68) ]
zeroRow = which( data1$interpolated_acetic ==0)
boxData1$interpolated_acetic[zeroRow] = boxData1$interpolated_acetic[zeroRow] + epsilon

b = boxcox( interpolated_acetic ~. , data= boxData1 , plotit = F)
trans = b$x[ which.max(b$y) ]

boxCoxReg = lm( interpolated_acetic^trans ~. , data= data1[ , c(index - 1,68) ] )
summary(boxCoxReg)

##
```

```

## Call:
## lm(formula = interpolated_acetic^trans ~ ., data = data1[, c(index -
##           1, 68)])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.40752 -0.20447  0.04304  0.23868  1.35800
##
## Coefficients:
##                               Estimate Std. Error
## (Intercept)                -5.0640476 4.3154967
## vent.flow                  0.0064701 0.0004943
## Station.3.Loop.Temperature 0.0058647 0.1619823
## Station.5.Loop.Temperature -0.0549153 0.1559411
## pH.at.stn1                 3.1245376 0.1973413
## CH4.in.offgas..              0.3570049 0.0996701
## CO2.in.offgas..              0.3941572 0.0767540
## dissolved.oxygen.at.stn1    -0.0171529 0.0150737
## dissolved.oxygen.at.stn5    0.0237353 0.0035909
## methane.flow.stn2            -0.1517660 0.0983647
## methane.flow.stn3            0.5185342 0.0354897
## oxygen.flow.stn2             0.2817294 0.0761602
## oxygen.flow.stn4              0.2570714 0.0200675
## optical.density              -0.5132055 0.0550366
## ammonia.pump.flow.1          -0.9637276 0.0542343
## Tempered.Water.Temperature.before.Temped.water.cooler -0.4744236 0.0792697
## Cooling.Water.Return.for.Temped.System                  -0.0111247 0.0085310
## Cooling.loop.A.valve.opening..                         0.0053436 0.0017923
## Cooling.loop.B.valve.opening..                         0.0048900 0.0011094
## Pressure.at.the.end.of.the.loop                      -0.6818121 0.2416972
## oxygen..pressure.to.fermentor.loop.mixture            1.0625636 0.2964811
## phosphoric.acid.flow                                -1.6439287 0.0940194
## trace.elements.flow                                 -0.7355275 0.1096590
## ferrus.sulphate.flow                                -0.7479870 0.0821008
## magnesium.potassium.flow                          -0.1996381 0.0355161
## spare.dosing.pump.flow                            0.3794082 0.0320374
##
## t value Pr(>|t|)
## (Intercept)                -1.173 0.240744
## vent.flow                  13.088 < 2e-16 ***
## Station.3.Loop.Temperature 0.036 0.971122
## Station.5.Loop.Temperature -0.352 0.724757
## pH.at.stn1                 15.833 < 2e-16 ***
## CH4.in.offgas..              3.582 0.000349 ***
## CO2.in.offgas..              5.135 3.07e-07 ***
## dissolved.oxygen.at.stn1    -1.138 0.255276
## dissolved.oxygen.at.stn5    6.610 4.84e-11 ***
## methane.flow.stn2            -1.543 0.123006
## methane.flow.stn3            14.611 < 2e-16 ***
## oxygen.flow.stn2             3.699 0.000222 ***
## oxygen.flow.stn4              12.810 < 2e-16 ***
## optical.density              -9.325 < 2e-16 ***
## ammonia.pump.flow.1          -17.770 < 2e-16 ***
## Tempered.Water.Temperature.before.Temped.water.cooler -5.985 2.53e-09 ***
## Cooling.Water.Return.for.Temped.System                -1.304 0.192360

```

```

## Cooling.loop.A.valve.opening..          2.981 0.002901 ***
## Cooling.loop.B.valve.opening..          4.408 1.10e-05 ***
## Pressure.at.the.end.of.the.loop       -2.821 0.004833 **
## oxygen..pressure.to.fermentor.loop.mixture 3.584 0.000346 ***
## phosphoric.acid.flow                 -17.485 < 2e-16 ***
## trace.elements.flow                  -6.707 2.53e-11 ***
## ferrus.sulphate.flow                -9.111 < 2e-16 ***
## magnesium.potassium.flow           -5.621 2.15e-08 ***
## spare.dosing.pump.flow              11.843 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.384 on 2133 degrees of freedom
## Multiple R-squared:  0.7785, Adjusted R-squared:  0.7759
## F-statistic: 299.9 on 25 and 2133 DF,  p-value: < 2.2e-16
plot(boxCoxReg)

```

