OHcomplianceStrategiesPackage.R

DErr001

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```
#OHcomplianceStrategies Package
```

Phase 1, EN689 1995 - testing compliance for 1 measurement

Compliance, uncertain compliance or non-compliance can be evaluated for one measurement. Calculation of exposure index is performed (worker measurement/OEL). Compliance is achieved if the index is below or equal to 0.1. If the index is greater than 0.1 but lower/equal than 1, there is no decision ("UC") and additional measurements are necessary (at least three). Non-Compliance is accomplished if the measurement is greater than the OEL and/or if the exposure index is greater than 1. @param measurements One measurement under assessment @param OEL Occupational Exposure Limit of the agent @return Compliance ("C"), Non-Compliance ("NC") or Uncertainty of Compliance ("UC") @export

```
phase1EN1995_k1 <- function(measurements, OEL) {
  x1 <- measurements / OEL

  if (measurements > OEL || x1 > 1) {
    result <- "Non Compliant"  # Not compliant
  } else if (x1 <= 0.1) {
    result <- "Compliant"   # Compliant
  } else {
    result <- "Uncertain Compliance"  # Uncertain compliance
  }

  return(result)
}
```

Phase 1, EN689 1995 - testing compliance for at least 3 measurements

Compliance, uncertain compliance or non-compliance can be evaluated for at least three measurements. Calculation of exposure indeces is performed (worker measurement/OEL). Compliance is achieved if all indeces are below or equal to 0.25. If at least an index is greater than 0.25 but all indeces are lower/equal than 1 and the geometric mean of the measurements is lower/equal than 0.5, Compliance is accomplished. Contrarly, there is no decision ("UC"). There is Non-Compliance if at least a measurement is greater than the OEL and/or if at least an exposure index is greater than 1. @param measurements At least 3 measurements @param OEL Occupational Exposure Limit of the agent @return Compliance (C"), Non-Compliance ("NC") or Uncertainty of Compliance ("UC") @export

```
phase1EN1995_k <- function(measurements, OEL) {
  ratios <- samples / OEL

  if (any(measurements > OEL) || any(ratios > 1)) {
    result <- "Not Compliant"  # Not compliant
  } else if (any(ratios > 0.25) || geomean(measurements) > 0.5) {
    result <- "Uncertain Compliance"  # Uncertain compliance
  } else {
```

```
    result <- "Compliant"    # Compliant
  }

  return(result)
}
```

Phase 1, EN689 2018 - testing compliance for 3 measurements

Compliance, uncertain compliance or non-compliance of a SEG can be evaluated for three measurements. Compliance is achieved if all of the measurements are below or equal to 0.1xOEL. There is Uncertain Compliance if at least a measurement is greater than 0.1xOEL but below the OEL. There is Non-Compliance if at least a measurement is greater than OEL. @param measurements Three measurements @param OEL Occupational Exposure Limit of the agent @return Compliance ("C"), Non-Compliance ("NC") or Uncertainty of Compliance ("UC") @export

```
phase1EN2018_k3 <- function(measurements, OEL) {
  if (length(measurements) > 3) {
    stop("Dataset exceeds three measurements. Function will not run.")
  }
  compliance <- ifelse(any(measurements > OEL), "Not Compliant",
                       ifelse(any(measurements >= 0.1 * OEL), "Uncertain Compliance", "Compliant"))
  return(compliance)
}
```

Phase 1, EN689 2018 - testing compliance for 4 measurements

Compliance, uncertain compliance or non-compliance of a SEG can be evaluated for four measurements. Compliance is achieved if all of the measurements are below or equal to 0.15xOEL. There is Uncertain Compliance if at least a measurement is greater than 0.15xOEL but below the OEL. There is Non-Compliance if at least a measurement is greater than OEL. @param measurements Four measurements @param OEL Occupational Exposure Limit of the agent @return Compliance ("C"), Non-Compliance ("NC") or Uncertainty of Compliance ("UC") @export

```
phase1EN2018_k4 <- function(measurements, OEL) {
  if (length(measurements) > 4) {
    stop("Dataset exceeds three measurements. Function will not run.")
  }
  compliance <- switch(
    TRUE,
    any(measurements > OEL), "Not Compliant",
    any(measurements >= 0.15 * OEL), "Uncertain Compliant",
    "Compliant"
  )
  return(compliance)
}
```

Phase 1, EN689 2018 - testing compliance for 5 measurements

Compliance, uncertain compliance or non-compliance of a SEG can be evaluated for five measurements. Compliance is achieved if all of the measurements are below or equal to 0.2xOEL. There is Uncertain Compliance if at least a measurement is greater than 0.2xOEL but below the OEL. There is Non-Compliance if at least a measurement is greater than OEL. @param measurements Five measurements @param OEL Occupational Exposure Limit of the agent @return Compliance ("C"), Non-Compliance ("NC") or Uncertainty of Compliance ("UC") @export

```
phase1EN2018_k5 <- function(measurements, OEL) {
  if (length(measurements) > 5) {
```

```
    stop("Dataset exceeds three measurements. Function will not run.")
  }
  compliance <- if (any(measurements > OEL)) {
    "Not Compliant"  # Not compliant
  } else if (any(measurements >= 0.2 * OEL)) {
    "Uncertain Complaince"  # Uncertain compliance
  } else {
    "Compliant"   # Compliant
  }
  return(compliance)
}
```

Phase 2, EN689 1995 - testing compliance exceedance

The normal distribution of the measurements is operated, and 99.9th percentile and 95th percentile values are observed to assess the possible exceedance of the OEL. Compliance or "Green Area" is achieved if the value of the 99,9 the percentile is lower than the OEL, Uncertain Compliance or "Orange Area" is achieved if the value of the 95th percentile is lower than the OEL. Non Compliance or "Red Area" is achieved if the OEL is greater than the value of the 95th percentile. @param measurements measurements of the SEG under assessment @param OEL Occupational Exposure Limit of the agent @return Green Area, Orange Area or Red Area @export

```
phase2EN689.1995 <- function(measurements, OEL) {
  if (length(measurements) < 6) {
    stop("Error: At least 6 measurements are required.")
  }
  QN <- qnorm(0.999, mean(log(measurements)), sd(log(measurements)))
  QN1 <- qnorm(0.95, mean(log(measurements)), sd(log(measurements)))
  if(QN < log(OEL))
  {print("Green Area")}
  else if(QN1 < log(OEL))
  {print("Orange Area")}
  else if(QN1 > log(OEL))
  {print("Red Area")}}
```

Phase 2, BOHS/NVvA & EN689 2018 - U test

This function applies the Mann-Whitney U test (70% Confidence) to evaluate SEG compliance based on the number of measurements performed.

The test compares the calculated U value (pg. 42, EN689 2018) with the U threshold from the Mann-Whitney U table: - If $\mathbf{U > OEL}$, there is **Compliance**. - If $\mathbf{U < OEL}$, there is **Non-Compliance**.

The function includes U-thresholds for a maximum of 15 measurements per SEG.

@param measurements Numeric vector. Measurements of the SEG under assessment (between 6 and 15). @param OEL Numeric. The Occupational Exposure Limit of the agent.

@return A character string: - "Compliant" if `U < threshold` - "Not Compliant" if `U > threshold`

@export

```
phase2_Uvalue <- function(measurements, OEL) {
  if (length(measurements) < 6) {
    stop("Error: At least 6 measurements are required.")
  }

  # Calculate U-value
```

```
  U <- (log(OEL) - log(geomean(measurements))) / log(geosd(measurements))

  # Define threshold values based on the number of samples
  thresholds <- c(2.005, 2.035, 2.072, 2.120, 2.187)
  threshold <- thresholds[min(length(measurements), length(thresholds))]

  # Check compliance
  if (U < threshold) {
    result <- "Compliant"
  } else {
    result <- "Not Compliant"
  }

  return(result)
}
```

Phase 2, EN689 2018 - UTLv (Upper Tolerance Limit value)

This function evaluates compliance with the Occupational Exposure Limit (OEL) based on the Upper Tolerance Limit value (UTLv), calculated with a 95% Percentile Confidence Level and a 70% Confidence Level.

The test compares the UTLv with the OEL: - If **UTL > OEL**, there is exceedance → **"Not Compliant"**. - If **UTL < OEL**, the probability of exceedance is acceptable → **"Compliant"**.

@param measurements Numeric vector. At least 6 exposure measurements from the SEG under assessment. @param OEL Numeric. The Occupational Exposure Limit of the agent. @return A character string: - `"Not Compliant"` if `UTL > OEL` - `"Compliant"` if `UTL < OEL`

@export

```
phase2_UTL <- function(measurements, OEL) {
  if (length(measurements) < 6) {
    stop("Error: At least 6 measurements are required.")
  }

  # Calculate upper tolerance limit (UTL)
  TL <- normtol.int(log(measurements), alpha = 0.3, P = 0.95, side = 1)
  UTL <- exp(TL$`1-sided.upper`)

  # Check compliance
  if (UTL < OEL) {
    result <- "Compliant"
  } else {
    result <- "Not Compliant"
  }

  return(result)
}
```

Phase 3, BOHS/NvVA 2011 - Between Worker Variance

Linear Mixed models using REML (Restricted Maximum Likelihood) is performed to calculate between worker variance and total variance. The Compliance is achieved if the between worker variance is lower than 0.2 of the total variance. Contrarily, there is Non-Compliance. @param seg data of SEG under assessment @param measurements samples concentrations of the agent @param workers workers codes/names/ID @return BW < 0.2totalVariance ("Compliant"), BW > 0.2totalVariance ("Not Compliant") @export

```r
phase3_BoHS.NvVA <- function(seg, workers, measurements) {
  if (length(measurements) < 6) {
    stop("Error: At least 6 measurements are required.")
  }
  # Fit linear mixed-effects model
  model <- lmer(measurements ~ 1 + (1 | workers), data = seg)

  # Extract variance components
  VC_random <- VarCorr(model)
  vc_df <- as.data.frame(VC_random)
  bw <- vc_df$vcov[1]
  ww <- vc_df$vcov[2]

  # Calculate total variance
  total_variance <- bw + ww

  # Check compliance
  if (bw < 0.2 * total_variance) {
    result <- "Compliant"
  } else {
    result <- "Not compliant"
  }

  return(result)
}
```

Phase 3, BOHS/NVVA 2011 - Individual Compliance

Individual Compliance is achieved when there is less than 20% probability that workers in a SEG have more than 5% of exposure greater than the OEL. @param seg data of the SEG under assessment @param measurements samples concentrations of the agent @param workers workers code/name @param OEL Occupational Exposure Limit @return BW $<$ 0.2totalVariance, Compliant or Not Compliant @export

```r
Individual_Compliance <- function(seg, workers, measurements, OEL) {
  # Calculate mean samples by workers
  M <- seg %>%
    group_by(workers) %>%
    na.omit() %>%
    summarise(mean = mean(log(measurements)))

  # Calculate overall mean of samples
  M1 <- mean(M$mean)

  # Fit linear mixed-effects model
  t <- lmer(measurements ~ 1 + (1 | workers), data = seg)

  # Extract variance components
  VCrandom <- VarCorr(t)
  vv <- as.data.frame(VCrandom)

  # Calculate standard deviations
  wwsd <- sqrt(vv$vcov[2])
  bwsd <- sqrt(vv$vcov[1])

  # Calculate compliance index
```

```
  H <- (log(OEL) - (M1 + 1.645 * wwsd)) / bwsd
  IE <- 1 - pnorm(H)

  # Determine compliance status
  if (IE < 0.2) {
    result <- "Compliant"
  } else {
    result <- "Not Compliant"
  }

  return(result)
}
```

OverExposure

OverExposure Calculation @param measurements measurements (with repeated measurements) of the SEG under assessment @param workers workers codes/ID @param samples exposure concentrations of workers @param OEL Occupational Exposure Limit of the agent @return probability of OverExposure @export

```
OverExp <- function(measurements, workers, samples, OEL) {
  # Calculate mean concentration samples by workers
  mean_samples <- measurements %>%
    group_by(workers) %>%
    summarise(mean_samples = mean(measurements)) %>%
    pull(mean_samples)

  # Calculate overall mean of samples
  overall_mean <- mean(mean_samples)

  # Fit linear mixed-effects model
  model <- lmer(measurements ~ 1 + (1 | workers), data = seg)

  # Extract variance components using broom
  VC_random <- tidy(VarCorr(model))

  # Calculate standard deviations
  wwsd <- sqrt(VC_random$stddev[2])
  bwsd <- sqrt(VC_random$stddev[1])

  # Calculate overexposure
  overexpos <- (log(OEL) - (overall_mean + 0.5 * wwsd)) / bwsd

  # Calculate probability of overexposure
  prob_overexposure <- 1 - pnorm(overexpos)

  return(prob_overexposure)

}
```

Exceedance

Probability of the OEL exceedance of the SEG considered @param measurements measurements of the SEG under assessment @param OEL Occupational Exposure Limit of the agent @return probability of Exceedance @export

```r
Exceedance <- function(measurements, OEL) {
  # Calculate geometric mean
  GM <- exp(mean(log(measurements)))

  # Calculate geometric standard deviation
  GSD <- exp(sd(log(measurements)))

  # Calculate exceedance
  Exc <- (log(OEL) - log(GM)) / log(GSD)

  # Calculate probability of exceedance
  prob_exceedance <- 1 - pnorm(Exc)

  return(prob_exceedance)
}
```