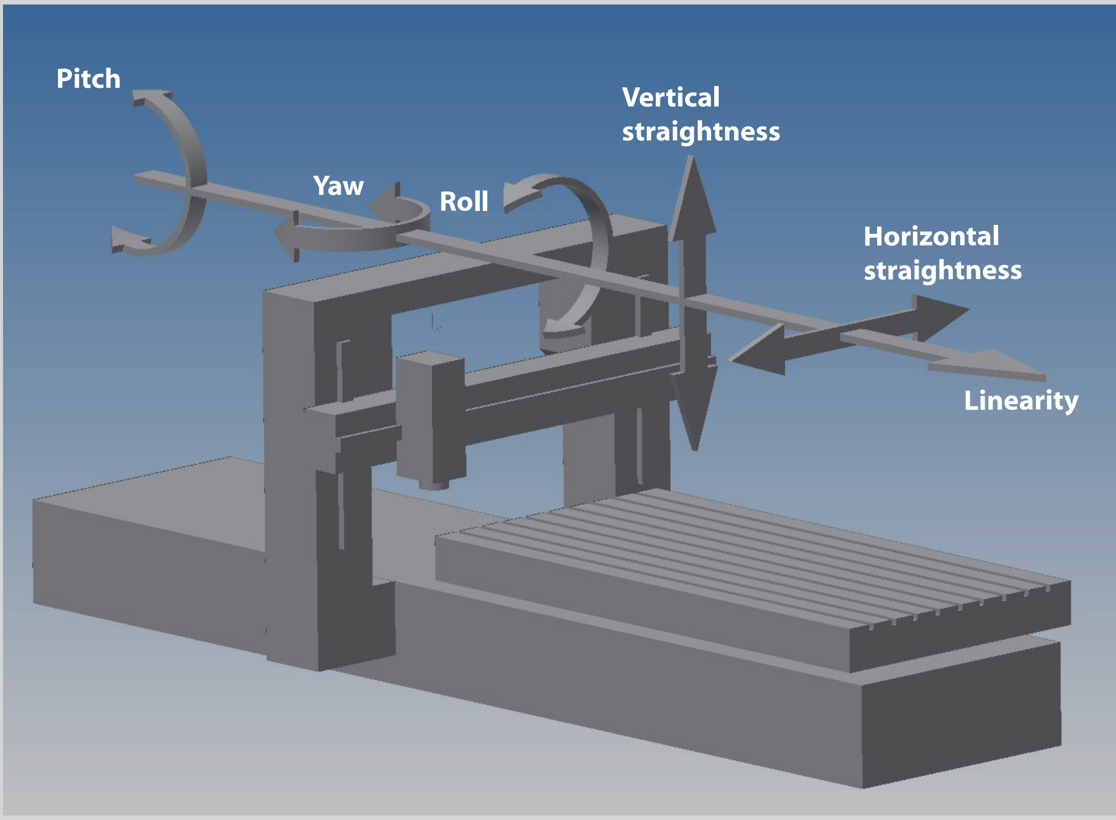
Flexium+ VEComp

(Volumetric Error Compensation)

Instruction manual

M00045EN-00

Edition 04.2016



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1 Foreword

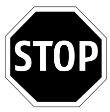
1.1 Use of the manual

This manual is for use by qualified personnel only.

To reduce the risk due to an improper use of the product, do not perform any servicing other than that contained in this manual unless you are qualified to do so.

To ensure proper use of these products, please always read this User's manual carefully and retain for future reference. Should the unit require maintenance, please contact a NUM authorized service center only.

1.2 Use of symbols in the manual

Symbol	Meaning of the symbol
	Important notes on product use.
	You may find this symbol whenever a wrong operation may damage the product.

1.3 Document revisions

Date	Index	Reason for revision	See chapter
04 - 2016	00	Document creation	-

1.1 How to read the manual

This manual gives information about the *VEComp function (Volumetric Error Compensation)* option and its customization to a particular machine.

Chapter	Description
1	**Foreword** This chapter introduces: - The use of the manual.
2	**General** This chapter introduces the use of VEComp
3	**VEComp: Definitions and data file** This chapter introduces: - Motion errors (Linear axis and rotary axes. - Location errors (position and orientation) - Machine description, cration of data file for VEComp and Programmind VEComp.
4	**VEComp Rotary: Defnitions and files** This chapter introduces: - Targeted kinematic chains ... - Model of a rotary axis according to standard ISO230-1 and machine description. - Data fles for VEComp Rotary and programming.
5	**Integrations** This chapter introduces: - Machine parameters.
A	**Appendix** This chapter introduces: - List of VEComp Exxxxx parameters. - List of VEComp errors.

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1.4 NUM Agencies

The list of NUM agencies is given click here http://www.num.com

1.5 Index

The general index at the end of the manual facilitates access to information by keywords.
Please click here index

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2 General

Regardless of the manufacturing quality, there is no perfect machine and geometric errors always exist.

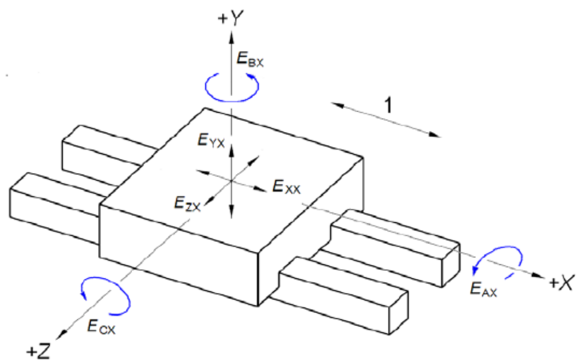
The errors are linked to the components geometric and dimensional manufacturing tolerances and misalignments, motion errors, thermal deformation, dynamic and structural deformations under load.

Each axis of a machine is affected by systematic and random errors. Systematic errors are reproducible and random errors (e.g. linked to cutting condition, acceleration, thermal deformation) more difficult to model.

VEComp function (Volumetric Error Compensation) deals with systematic errors by modeling the machine reaction.

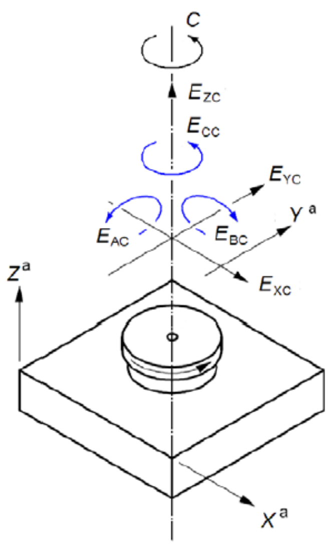
Systematic errors on linear axes are:

- Longitudinal positioning accuracy
- Vertical straightness
- Horizontal straightness
- Pitch, Roll and Yaw.



Systematic errors on Rotary axes are:

- Axial linear zero offset error
- Two off centering offsets
- Axial rotational positioning error
- Two tilt angles.



These errors and their denomination will be described with more details in the following chapters.

Additionally, the perpendicularity of linear axis cannot be perfectly assured. Therefore for a three axis machine we will have at each position 21 error parameter.

- Three non-perpendicularity
- Three times six linear axes errors.

One can understand that according to the machine kinematics, such errors will accumulate and superpose **in a certain order**. This error accumulation will have an effect on the accuracy of the tool center point positioning.

The VEComp function is intended to compensate these errors.

For this it requires knowledge of all individual errors measured with the highest accuracy in stable ambient conditions as well as the machine kinematic structure description in order to build the model used to calculate and annihilate the combined effect of all errors.

Chapters 3 to 4 are dedicated to the setting of VEComp and VEComp rotary.

This operation is performed once (after measurement).

Chapter 5 and Appendix is dedicated to part programming.

VEComp is available on Flexium$^+$ and exists in two versions.

Compensations of the linear and rotary axes errors in two declinations [(1)]:

- **VEComp 3/4 axes**: Compensation of location and orientation (perpendicularity) errors as well as the 6 motions errors for three linear axes + a rotary table or three linear axes including one gantry.
- **VEComp 5 axes**: This function allows the same compensation for a five axes machine (plus gantry if necessary). The TCP deviations are compensated as well when RTCP is active.

- Compensation of errors related to rotary axes on five axes machine. Due to leverage effect such errors might results in important deviations increasing with the distance from the axis origin.
  - **VEComp Rotary** : This function is intended to compensate the errors related to rotary axes on five axes machines.

[(1)] The different structures that are currently managed by VEComp are described in the annex A.

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3 VEComp: Definitions and data files

This chapter describes, according to the ISO 230-1 and TR 16907 standards, the different types of structural errors that can be encountered on a machine.

They are two main categories of errors each for linear or rotary axes:

- Motion errors: these errors vary according to the axis movement.
- Location and orientation errors : misalignments – invariant with respect to axis movements.

3.1 Motion errors

3.1.1 Linear axis

Each linear axis has, as described above, six motion errors: three linear (longitudinal, vertical and transverse), as well as three angular (roll, pitch and yaw).

Linear deviations have a direct influence on machine path accuracy and a small angular error can cause a significant effect at the tool center point.

We will name these errors: ***Deviations***.

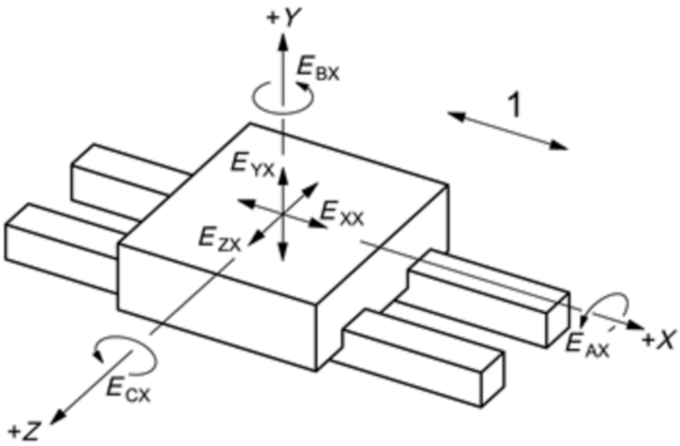
The positive sign of the angular position errors follows the right-hand rule.

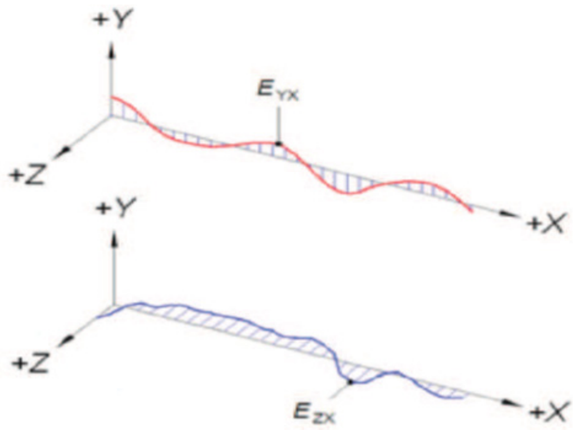
3.1.1.1 Standard notations

The deviations are noted by three characters:

- **1st character: E** followed by:
- **2nd character**: direction of the deviation (angular deviation with A, B or C letter, linear deviation with X, Y or Z letter).
- **3rd character**: Name of the axis.

Example of straightless deviation of X in Y- axis direction and on Z-axis direction (figures from ISO 230-1:2012-05)





3.1.1.2 Normalized denomination

Each deviation depends on the current position of the axis.

Deviations relative to X linear axis	
EAX	Angular deviation around A-axis (Roll)
EBX	Angular deviation around B-axis (Pitch)
ECX	Angular deviation around C-axis (Yaw)
EXX	Motion deviation of X-axis
EYX	Deviation in Y-axis direction (straightness imperfection)
EZX	Deviation in Z-axis direction (straightness imperfection)

Deviations relative to Y linear axis	
EAY	Angular deviation around A-axis (Pitch)
EBY	Angular deviation around B-axis (Roll)
ECY	Angular deviation around C-axis (Yaw)
EXY	Deviation in X-axis direction (straightness imperfection)
EYY	Motion deviation of Y axis
EZY	Deviation in Z-axis direction (straightness imperfection)

Deviations relative to Z linear axis	
EAZ	Angular deviation around A-axis (Pitch)
EBZ	Angular deviation around B-axis (Yaw)
ECZ	Angular deviation around C-axis (Roll)
EXZ	Deviation in X-axis direction (straightness imperfection)
EYZ	Deviation in Y-axis direction (straightness imperfection)
EZZ	Motion deviation of Z-axis

3.1.2 Rotary axes

Each rotary axis motion can also be affected by six motion errors (i.e. one axial, two radial, an angular position deviation and two tilt error: wobble effect).

3.1.2.1 Standard notations

Each rotary axis motion can also be affected by six motion errors (i.e. one axial, two radial, an angular position deviation and two tilt error: wobble effect).

Geometric deviation on rotary axis

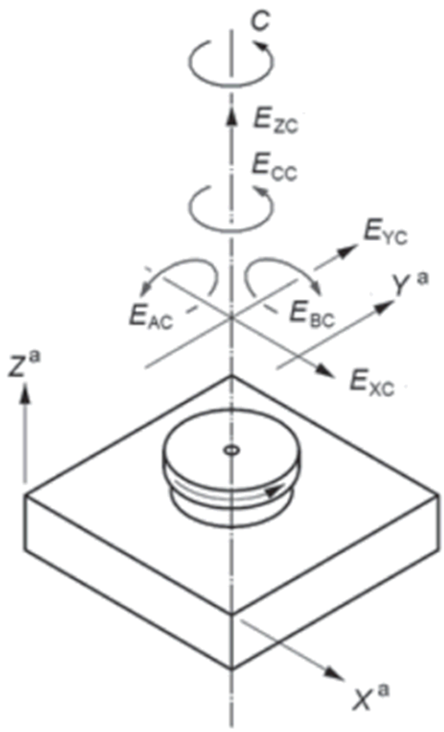


Figure. Angular and linear error motions of an C rotary axis.

3.1.2.2 Normalized denomination

Each error motion depends on the current position of the axis motion.

Deviations of A axis	
EAA	Angular motion deviation of A axis
EBA	Tilt deviation around Y-axis (wobble)
ECA	Tilt deviation around Z-axis (wobble)
EXA	Axial deviation of A-axis
EYA	Radial deviation in the Y-axis direction
EZA	Radial deviation in the Z-axis direction

Deviations of B axis rotational motion	
EAB	Tilt deviation around X-axis (wobble)
EBB	Angular motion deviation of B
ECB	Tilt around Z-axis deviation (wobble)
EXB	Radial deviation in the X-axis direction
EYB	Axial deviation of B-axis
EZB	Radial deviation in the Z-axis direction

Deviations of C axis rotational motion	
EAC	Tilt deviation around X-axis (wobble)
EBC	Tilt deviation around Y-axis
ECC	Angular motion deviation of C axis
EXC	Radial deviation in the X-axis direction
EYC	Radial deviation in the Y-axis direction
EZC	Axial deviation of C-axis

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3.2 Location errors (position and orientation)

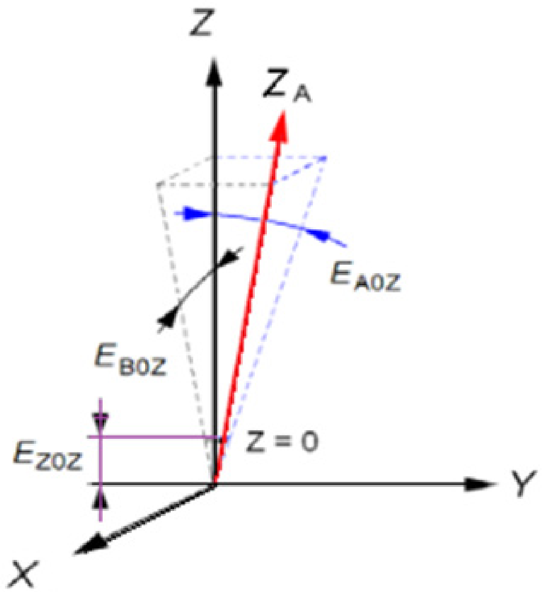
3.2.1 Standard notation

- 1st letter **E** followed by:
- 2nd letter deviation direction (A, B, C for angular deviation) (X, Y, Z for linear deviation)
- 3rd letter is the numeral 0 (zero)
- 4th letter is the name of the axis.

3.2.1.1 Linear axes

A linear axis is defined by its reference line whose direction is given by two orientations with respect to the reference coordinates axes.

The orientation errors are defined as below (example for a Z axis).



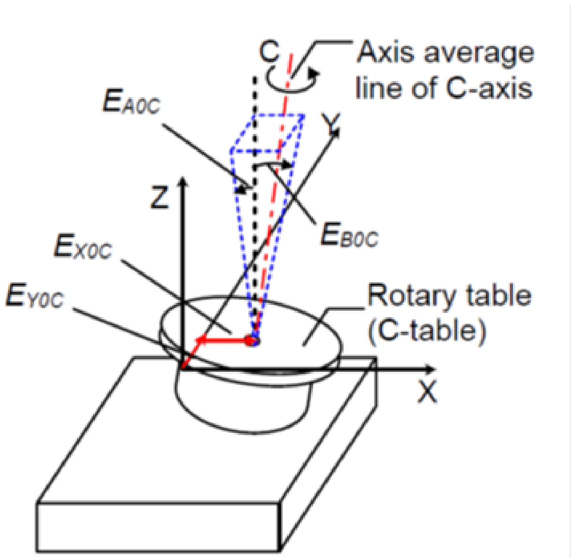
- **ZA:** Reference line of the axis motion along Z-direction
- **EZ0Z:** Zero position error
- **EA0Z:** Perpendicularity error with respect to Y
- **EB0Z:** Perpendicularity error with respect to X.

3.2.1.2 Rotary axes

A rotary axis is defined by its axes average line given by the five following variables:

- Two motion error coordinates
- Two tilt angles
- A zero position error with respect to a reference frame X^a, Y^a, Z^a.

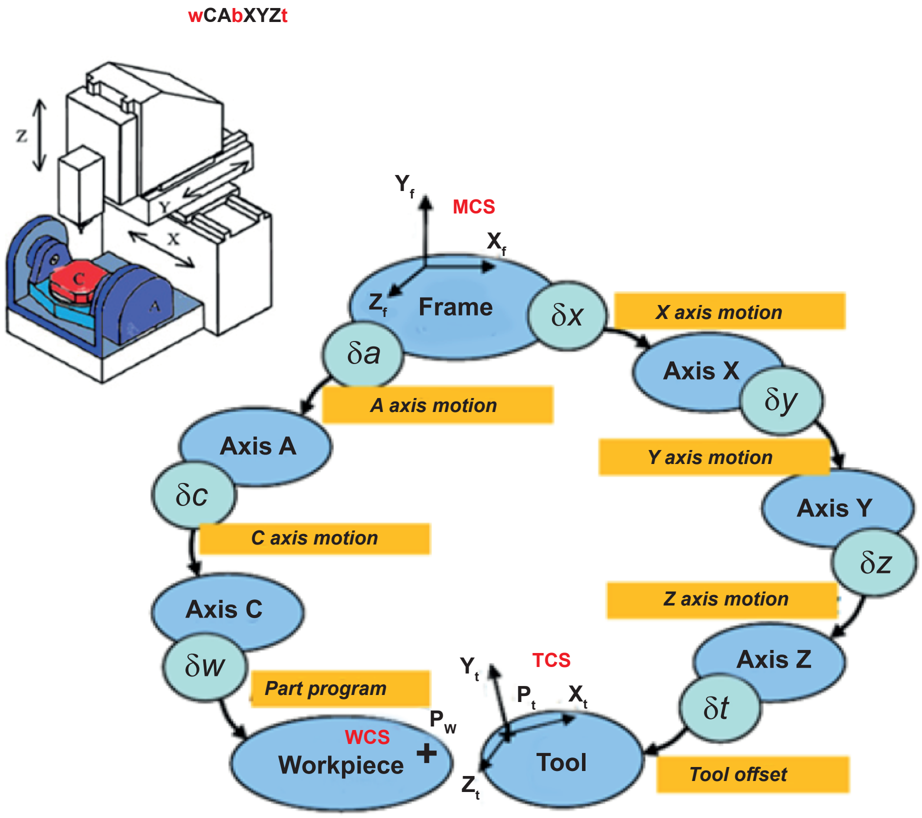
The position and orientation errors are defined as below (example for a C axis):



- **EX0C:** Position error in the X direction
- **EY0C:** Position error in the Y direction
- **EA0C:** Perpendicularity error relative to Y
- **EB0C:** Perpendicularity relative to X
- **EC0C:** Zero position error.

3.3 Machine description

The machine description is made starting for the workpiece to the machine bed and then to the tool center. Below is an example of this description:



Starting from the part (workpiece) **"w"** we find successively C axis, A axis, the machine bed **"b"** then X Y Z axis in this order and finally the tool **"t"** which explains the description **wCAbXYZt** characteristic of this particular machine.

3.3.1 Example

In this description, the work-piece side and the tool side are distinguished by naming the workpiece by “**w**”, the tool by “**t**”, and the bed (or foundation of the machine) by **“b”**.

- (C1) stands for the spindle axis without numerical control for angular positioning and the C letter (A or B letter) in brackets stands the tool holder axis is in Z axis direction. (X axis or B axis direction)
- ABC respectively XYZ letters at workpiece side define rotary (or tilting) tables respectively linear saddle tables.

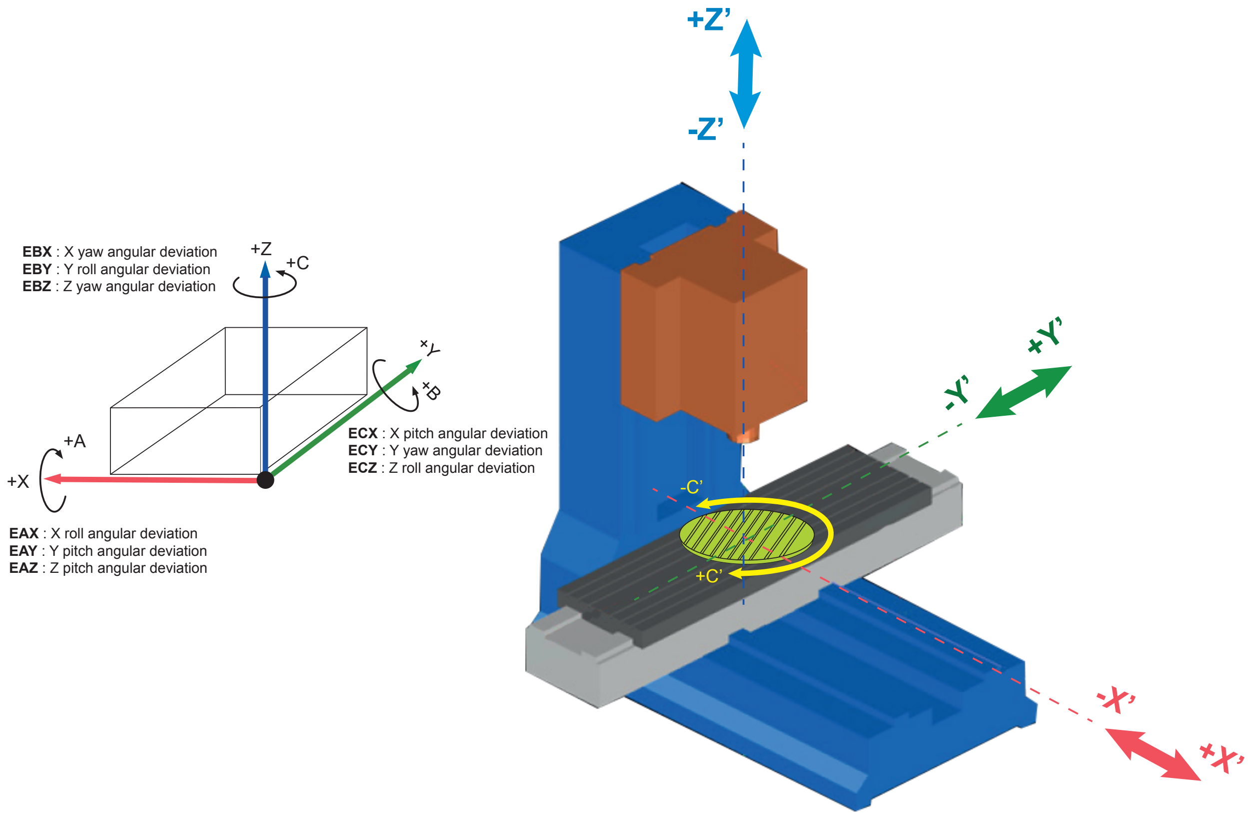


Figure. Vertical Machining Center with rotary table on cross saddle tables, described by [wCYXbZ(C1)t].

3.4 Data files

The measurement data are given by several file (one per axis).

Such files, similar to part programs using symbolic variables, have the following structure:

```
%16000 (fx_VECOMP_16000)()
( *** X AXIS ERROR MOTIONS *** )
( EXX[nx] positioning error of X axis)
( EYX[nx] straightness error in Y direction)
( EZX[nx] straightness error in Z direction)
( EAX[nx] angular error around X axis)
( EBX[nx] angular error around Y axis)
( ECX[nx] angular error around Z axis)
[L_Err_U]=3 (in mm)
[A_Err_U]=1 (in rad)
(index)                (X position Err)             (deviation along Z)              (Yaw angle error)
     (X position in mm)              (deviation along Y)              (Roll angle error)               (Pitch angle error)
N1
[nx]=1  [X(nx)]= -1600 [EXX(nx)]= 0   [EYX(nx)]= -60  [EZX(nx)]= 10   [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=2  [X(nx)]= -1500 [EXX(nx)]= 0   [EYX(nx)]= -60  [EZX(nx)]= 10   [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=3  [X(nx)]= -1400 [EXX(nx)]= 9   [EYX(nx)]= -70  [EZX(nx)]= 0    [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=4  [X(nx)]= -1300 [EXX(nx)]= 11  [EYX(nx)]= -70  [EZX(nx)]= -10  [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=5  [X(nx)]= -1200 [EXX(nx)]= 16  [EYX(nx)]= -60  [EZX(nx)]= -10  [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=6  [X(nx)]= -1100 [EXX(nx)]= 18  [EYX(nx)]= -50  [EZX(nx)]= -20  [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0

                                        Other data lines (Maximum 200)

[nx]=198 [X(nx)]= 0.0  [EXX(nx)]= 0.0  [EYX(nx)]= 0.0  [EZX(nx)]= 0.0  [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=199 [X(nx)]= 0.0  [EXX(nx)]= 0.0  [EYX(nx)]= 0.0  [EZX(nx)]= 0.0  [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
[nx]=200 [X(nx)]= 0.0  [EXX(nx)]= 0.0  [EYX(nx)]= 0.0  [EZX(nx)]= 0.0  [EAX(nx)]= 0.0  [EBX(nx)]= 0.0  [ECX(nx)]= 0.0
N200 (END OF DATA)
```

The data (max 200 sets) are stored between N1 and N200.

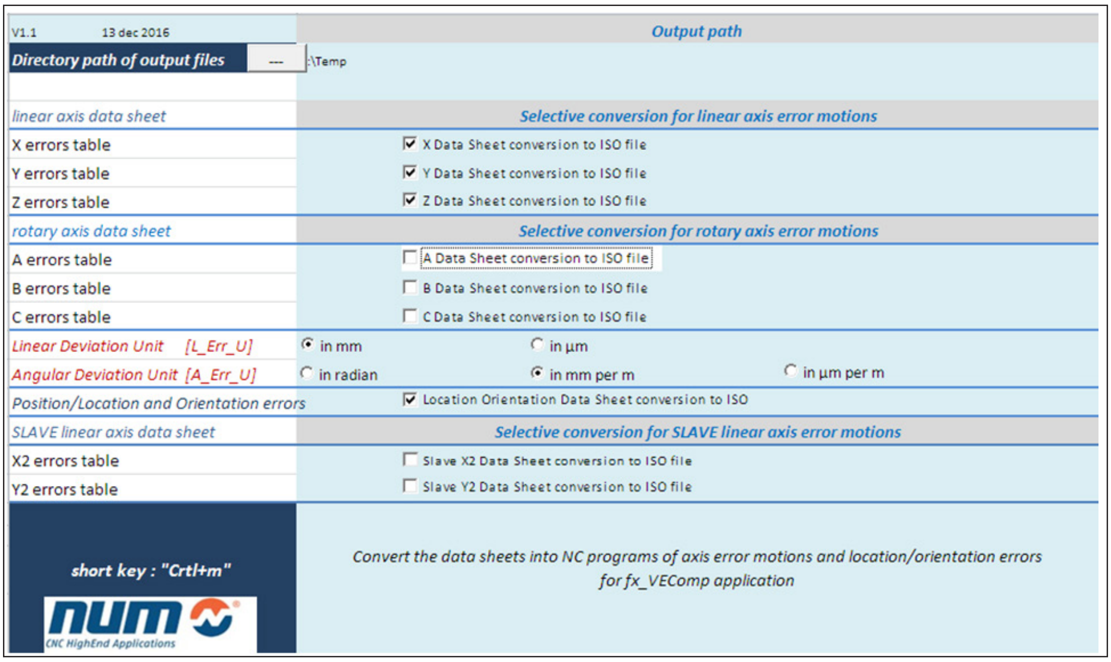
Each type of deviation is defined by the normalized denomination.

Axes positions are always defined in mm. The deviations can be expressed in:

- mm ([L_Err_U] = 3) or μm ([L_Err_U] = 6) for linear axes
- rad ([A_Err_U] = 1), mm/m ([A_Err_U] = 3), μm/m ([A_Err_U] = 6) for rotary axes.

3.5 Creation of data files for VEComp

An **Excel tool (Data VEComp.xlsm)** has been developed to facilitate formatting of the data files created by the metrology in a structure acceptable by VEComp.



The file opens with the general settings page.

The tabs provide access to the data sheets of deviations for each axis as well as to the data sheet of position/location and orientation errors.

- Enter the required setting (path of output files, data sheets in use and units)
- Fill in the measurements data generally by cut and paste if the measuring system follows the standard denomination
- Press *Ctrl + M* (Macros must be activated); Macro files in ISO format will be created in the speci fied directory
- Transfer the macros to the NCK.

3.6 Customization file: “fx_VEComp_Settings.XPI”

In addition to the data files the VEComp macro uses a configuration file defined as below.

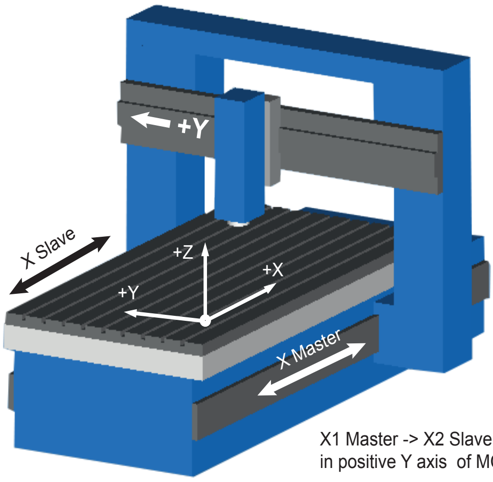
Symbolic variables description	
Physical axis addresses	• *[addrX], [addrY] and [addrZ]* for addressing respectively the X, Y and Z main linear axes. • *[addrU], [addrV] and [addrW]* for addressing respectively the U, V or W secondary linear axes. • *[addrA], [addrB] and [addrC]* for addressing respectively A, B and C rotary axes. • *[addrX2], [addrY2]* dedicated to the X2 and Y2 linear slave axes. Note: Refer to machine parameter P9 for definition of the physical addresses. A missing axis is identified by a -1 value.
E parameter starting addresses	VEComp requires 31 E80xxx parameters. For compatibility with existing applications the starting address can be defined by this data. The default address values are: • *[E80xxx]=80100* start address of E80xxx array. • *[E83xxx]=83000* start address of E83xxx array. • *[E84xxx]=84000* start address of area only used for quick watch only.
Command word to selectively enable / disable the deviation compensations per axis	This can prove to be is useful during measurements. • *[CMP_En_XErrMotion]* enable/disable the compensation of the X deviations. • *[CMP_En_YErrMotion]* enable/disable the compensation of the Y deviations. • *[CMP_En_ZErrMotion]* enable/disable the compensation of the Z deviations.
Command word to selectively enable / disable the location / orientation compensations	• *[CTRL_En_LocErr_X]* enable/disable the location/orientation compensation of X axis • *[CTRL_En_LocErr_Y]* enable/disable the location/orientation compensation of Y axis • *[CTRL_En_LocErr_Z]* enable/disable the location/orientation compensation of Z axis • *[CTRL_En_LocErr_A]* enable/disable the location/orientation compensation of A axis • *[CTRL_En_LocErr_B]* enable/disable the location/orientation compensation of B axis • *[CTRL_En_LocErr_C]* enable/disable the location/orientation compensation of C axis • *[CTRL_En_LocErr_U]* enable/disable the location/orientation compensation of U axis • *[CTRL_En_LocErr_V]* enable/disable the location/orientation compensation of V axis • *[CTRL_En_LocErr_W]* enable/disable the location/orientation compensation of W axis • *[CTRL_En_LocErr_S]* enable/disable the location/orientation compensation of Spindle C1 axis or B1 axis or A1 axis • *[CTRL_En_LocErr_X2]* enable/disable the location/orientation compensation of X2 slave axis. • *[CTRL_En_LocErr_Y2]* enable/disable the location/orientation compensation of Y2 slave axis.

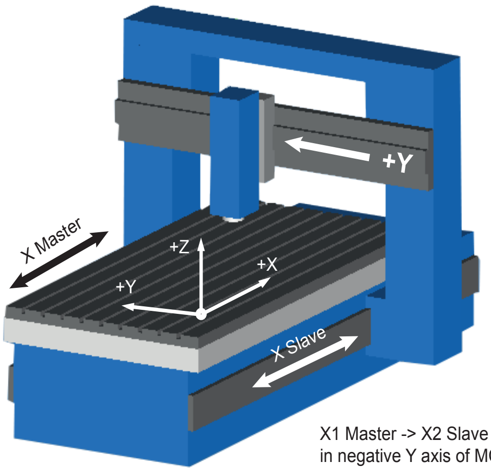
Command word to selectively enable / disable the position error	**Keywords relative to X axis:** • *[CTRL_Enable_Exx]* enable the position compensation of X axis. • *[CTRL_Enable_Eyx]* enable the linearity compensation in Y direction. • *[CTRL_Enable_Ezx]* enable the linearity compensation in Z direction. • *[CTRL_Enable_Eax]* enable the angular compensation around A-axis. • *[CTRL_Enable_Ebx]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecx]* enable the angular compensation around C-axis
	Keywords relative to Y axis: • *[CTRL_Enable_Exy]* enable the linearity compensation in X direction • *[CTRL_Enable_Eyy]* enable the linear position compensation of Y-axis • *[CTRL_Enable_Ezy]* enable the linearity compensation in Z direction • *[CTRL_Enable_Eay]* enable the angular compensation around A-axis • *[CTRL_Enable_Eby]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecy]* enable the angular compensation around C-axis
	Keywords relative to Z axis: • *[CTRL_Enable_Exz]* enable the linearity compensation in X direction • *[CTRL_Enable_Eyz]* enable the linearity compensation in Y direction • *[CTRL_Enable_Ezz]* enable the linear position compensation of Z-axis • *[CTRL_Enable_Eaz]* enable the angular compensation around A-axis • *[CTRL_Enable_Ebz]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecz]* enable the angular compensation around C-axis
	Keywords relative to A axis: • *[CTRL_Enable_Exa]* enable the radial compensation of A in X direction • *[CTRL_Enable_Eya]* enable the radial compensation of A in Y direction • *[CTRL_Enable_Eza]* enable the axial compensation of A-axis • *[CTRL_Enable_Eaa]* enable the angular position compensation of A-axis • *[CTRL_Enable_Eba]* enable the tilt compensation of A around Y • *[CTRL_Enable_Eca]* enable the tilt compensation of A around Z
	Keywords relative to B axis: • *[CTRL_Enable_Exb]* enable the radial compensation of B in X direction • *[CTRL_Enable_Eyb]* enable the axial compensation of B-axis • *[CTRL_Enable_Ezb]* enable the radial compensation of B in Z direction • *[CTRL_Enable_Eab]* enable the tilt compensation of B around X • *[CTRL_Enable_Ebb]* enable the angular position compensation of B-axis • *[CTRL_Enable_Ecb]* enable the tilt compensation of B around Z
	Keywords relative to C axis: • *[CTRL_Enable_Exc]* enable the radial compensation of C in X direction • *[CTRL_Enable_Eyc]* enable the radial compensation of C in Y direction • *[CTRL_Enable_Ezc]* enable the axial compensation of C axis • *[CTRL_Enable_Eac]* enable the tilt compensation of C around X • *[CTRL_Enable_Ebc]* enable the tilt compensation of A around Y • *[CTRL_Enable_Ecc]* enable the angular position compensation of C
	Keywords relative to U axis: • *[CTRL_Enable_Exu]* enable the linear position compensation of U axis • *[CTRL_Enable_Eyu]* enable the linearity compensation in Y direction • *[CTRL_Enable_Ezu]* enable the linearity compensation in Z direction • *[CTRL_Enable_Eau]* enable the angular compensation around A • *[CTRL_Enable_Ebu]* enable the angular compensation around B • *[CTRL_Enable_Ecu]* enable the angular compensation around C
	Keywords relative to V axis: • *[CTRL_Enable_Exv]* enable the linearity compensation in X-axis direction • *[CTRL_Enable_Eyv]* enable the linear positioning compensation of V-axis • *[CTRL_Enable_Ezv]* enable the linearity compensation in Z-axis direction • *[CTRL_Enable_Eav]* enable the angular compensation around A-axis • *[CTRL_Enable_Ebv]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecv]* enable the angular compensation around C-axis

Command word to selectively enable / disable the position error	**Keyword relative to W axis:** • *[CTRL_Enable_Exw]* enable the linearity compensation in X-axis direction • *[CTRL_Enable_Eyw]* enable the linearity compensation in Y-axis direction • *[CTRL_Enable_Ezw]* enable the linear positioning compensation of W-axis • *[CTRL_Enable_Eaw]* enable the angular compensation around A-axis • *[CTRL_Enable_Ebw]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecw]* enable the angular compensation around C-axis
	Keywords relative to X2 slave axis: • *[CTRL_Enable_Exx2]* enable the linear positioning compensation of X2 axis • *[CTRL_Enable_Eyx2]* enable the linearity compensation in Y axis direction • *[CTRL_Enable_Ezx2]* enable the linearity compensation in Z axis direction • *[CTRL_Enable_Eax2*] enable the angular compensation around A-axis • *[CTRL_Enable_Ebx2]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecx2]* enable the angular compensation around C-axis
	Keywords relative to Y2 axis: • *[CTRL_Enable_Exy2]* enable the linearity compensation in X-axis direction • *[CTRL_Enable_Eyy2]* enable the linear positioning compensation of Y2-axis • *[CTRL_Enable_Ezy2]* enable the linearity compensation in Z-axis direction • *[CTRL_Enable_Eay2]* enable the angular compensation around A-axis • *[CTRL_Enable_Eby2]* enable the angular compensation around B-axis • *[CTRL_Enable_Ecy2]* enable the angular compensation around C-axis

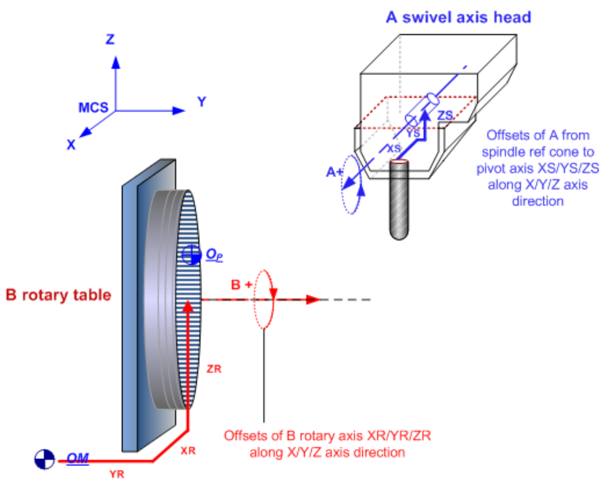
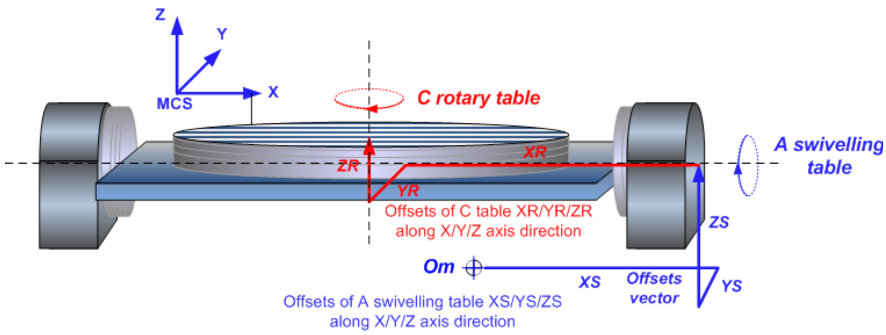
<table>
<tr>
<td>Configuration of master & slave axes driven in gantry</td>
<td>
The master and the slave axes both have their own its own table of deviations. VEComp applies a weighting to each deviations value depending of the relative position of the slide between the guides of the leading and following axes.

The same considerations can be applied to a master/slave Y1/Y2 saddles driven in gantry. This Keyword defines how to apply this weighting.

Master to Slave aligned along Y positive


Master to Slave aligned along Y negative


• [MSdir] =1 X master to X2 slave aligned in positive direction of Y axis.
• [MSdir] =1 Y master to Y2 slave aligned in positive direction of X axis.
• [MSdir] =-1 X master to X2 slave aligned in negative direction of Y axis.
• [MSdir] =-1 Y master to Y2 slave aligned in negative direction of X axis.
</td>
</tr>
</table>

Kinematic offsets of the rotary axis pivot point	**The offsets are oriented from the spindle reference point in direction of the bed and then the workpiece.** **Algebraic offsets of a Rotary axis identified by the R letter:** • *[XR_mm]* offset along x+ direction in mm. • *[YR_mm]* offset along y+ direction in mm. • *[ZR_mm]* offset along z+ direction in mm. **Algebraic offset of a Swivel axis identified by the S letter:** • *[XS_mm]* offset along x+ direction in mm. • *[YS_mm]* offset along y+ direction in mm. • *[ZS_mm]* offset along z+ direction in mm. **Examples of Kinematic offset**  **Kinematic offsets of a B rotary table and A swivel axis head combined** 
	Tool orientation in reference to the Head: (tool vector from tool tip to the spindle) • *[I]* X component of tool orientation unit vector. • *[J]* Y component of tool orientation unit vector. • *[K]* Z component of tool orientation unit vector. Offsets vector X4, Y4, Z4, used if an angle head is mounted on the tool holder as well as for the case of a twin-spindle milling head. Spindle offsets relative to the reference cone are expressed in mm. • *[X4]* x offset component from tool holder position to the spindle reference. • *[Y4]* y offset component from tool holder position to the spindle reference. • *[Z4]* z offset component from tool holder position to the spindle reference.

Dynamic features of the spatial error compensations	The variations of calculated compensations values are averaged in order to limit the dynamic of the 3D compensation. The acceleration and speed of these corrections are managed in a control loop with anti wind-up function. Then the smoothed compensation outputs are applied to E954xx parameters. • *[CMP_MxFeed]* Max feed of error compensation in mm/min. • *[CMP_MxAcc]* Acceleration of error compensation in mm/s^2.

3.7 Programming

VEComp requires several tables of data defining the measured machine imperfections.

The different categories of imperfections are described from chapter 3 on. It is not necessary to have a deep knowledge of them in order to use VEComp. It is however suggested to read them for a better understanding.

Once the set of imperfection errors have been defined and stored in the CNC validating VEComp is quite easy.

It requires:

- The definition of the kinematic structure *(machine characteristic – invariable)*
- Choice between two sets of offsets.
- Definition of the tool direction.
- Definition of the files containing the errors values *(machine characteristic - invariable)*.

The syntax for activating VEComp is as below.

3.7.1 Activation

The following syntax will activate the compensation once the axes are homed.

G246 T.. EK. ET.. EO. EX.. EY.. EZ.. EA.. EB.. EC.. EU.. EV.. EW.. ER.. ES..

G246	**G function of volumetric error compensation**
T	Code number of the kinematic structure (see annex)
EK	Number of the set of kinematic offsets (1 or 2). This is useful in case of multiple heads with different RTCP data.
ET	Tool direction: (optional – default = Direction Z) • 1 : Direction X • 2 : Direction Y • 3 : Direction Z
EO	Number of the file describing the location and orientation errors
EX	Number of the file describing the X linear axis error motions
EY	Number of the file describing the Y linear axis error motions
EZ	Number of the file describing the Z linear axis error motions
EU	Number of the file describing the U linear axis error motions
EV	Number of the file describing the V linear axis error motions
EW	Number of the file describing the W linear axis error motions
EA	Number of the file describing the A rotary axis error motions
EB	Number of the file describing the B rotary axis error motions
EC	Number of the file describing the C rotary axis error motions
ER	Number of the file describing the X2 linear axis error motions (case of gantry structure)
ES	Number of the file describing the Y2 linear axis error motions (case of gantry structure)

3.7.2 Inhibition of VEComp

Once the compensation has been activated it is possible to suspend it by the following syntax.

G246 S0

This will suspend the compensation and gradually clears the compensation.

3.7.3 Re-Activation

To re-activate the compensation after a suspend.

G246 EK. S1

The argument EK. allows for reading the first or second set of offsets.

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4 VEComp Rotary: Definitions and files

VEComp Rotary system is intended to compensate the following deviations of a rotary axis:

- Location errors of the axis i.e. two offsets of the center-point of rotation from an ideal center of rotation.
- Orientation errors of rotary axes, i.e. two perpendicularity errors from an ideal axis motion of rotation.
- Residual deviations in radial and axial direction, previously measured at indexed angular positions.
- Effects of incorrectly calibrated kinematic offsets for RTCP.

We recommend that its implementation is achieved when the linear X Y and Z axes have been previously calibrated. Without this precaution, the calibration results will be biased.

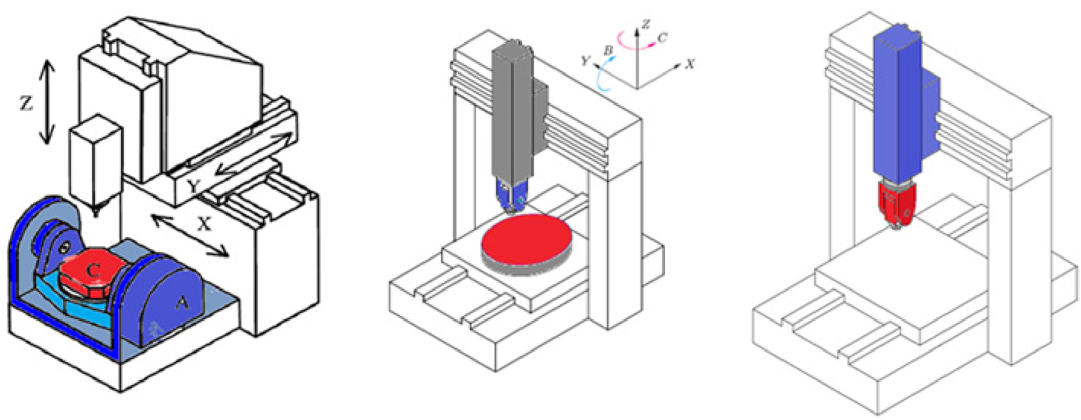
4.1 Targeted kinematic chains

VEComp Rotary system manages the following five axes machines with respect to the ISO 10791-6:2012 standard:

- Dual twist head machines (type-A).
- Tilting turntable or trunnion machines (type-B).
- Swivel head and rotary table combined (type-C).

- As well as conventional 4 axes machine with either one turntable or one swiveling axis head.

Example of configurations



4.2 Model of a rotary axis according to standard ISO230-1

According to the ISO 230 standard, the model of a rotary axis combines two kinds of errors:

- **Location errors (position and orientation)**

  These errors define a reference average line around which the rotation is performed.

  Location errors of a rotary axis are defined as shifts of the axis average line. In other words, location errors only represent the “average” error in the position and orientation of the axis of rotation.

  For a complete description please refer to Location errors of rotary axis in the VEComp section (chapter 3.2.2)

- **Motion errors (translation and rotation)**

  Errors function of the angular axis position.

  The ISO 230-7 standard defines these errors as “unintended relative displacement in the sensitive direction between the tool and the workpiece”.

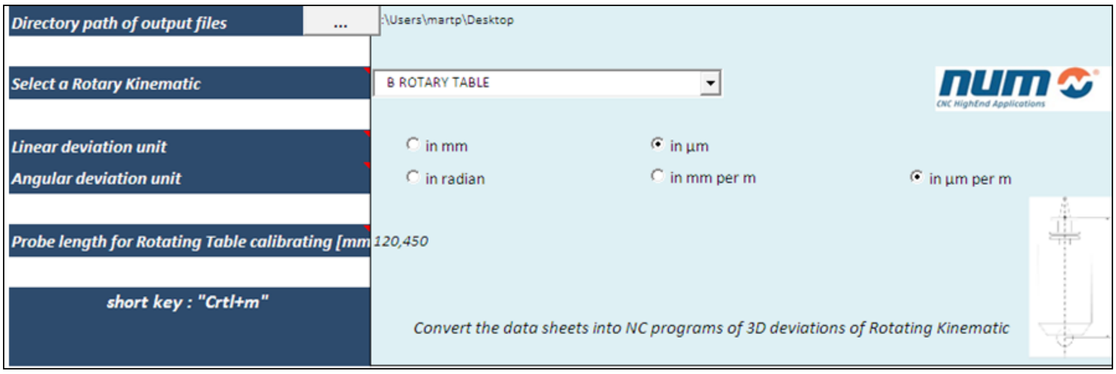
  For a complete description please refer to motion errors of rotary axis in the VEComp section (chapter 3.1.2).

4.3 Machine description

The different configurations accepted by VEComp Rotary are those managed by the RTCP function, described in the chapter annex A.7

4.4 Data files for VEComp Rotary

An excel tool *(Rotary VEC.xslm)* has been developed to facilitate formatting of the data files created by the metrology in a structure acceptable by VEComp Rotary.



The file opens with the general settings page.

The tabs provide access to the data sheets of deviations for each axis as well as to the data sheet of position/location and orientation errors.

- Enter the required setting (path of output files, data sheets in use and units).
- Select the kinematic.
- A data sheet corresponding to this kinematic will be created the field of data are conform to the standard denomination. You can fill them in by cut and paste if the measuring system also follows the standard denomination.
- Press *Ctrl + M* (Macros must be activated); an ISO file will be created in the specified directory.

Transfer this file to the NCK. The first ranges are linked to the rotary axis.

%18004	*(DUAL TWIST HEAD B SWIVEL AXIS ON C ROTARY AXIS)*			
N100				
(LOCATION and SQUARENESS ERRORS)				
	[EA0C]= 0.0	[EB0C]= 0.0	[EX0C]= 0.0	[EY0C]= 0.0
(PROBE REFERENCE POSITION)				
	[X0/TCP]= 0.0	[Y0/TCP]= 0.0	[Z0/TCP]= 0.0	[LPROBE]= 0.0
(DEVIATION UNITS)				
	[L_Err_U]=6 (in µm)	[A_Err_U]=6 (in µm/m)		
(index)	(C angle in degrees)	(X deviation)	(Y deviation)	(Z deviation)
N101				
[nc]=1	[C(nc)]= 0.0	[dXC(nc)]= -0.012	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
[nc]=2	[C(nc)]= 0.0	[dXC(nc)]= 0.0	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
[nc]=3	[C(nc)]= 0.0	[dXC(nc)]= 0.0	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
[nc]=69	[C(nc)]= 0.0	[dXC(nc)]= 0.0	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
[nc]=70	[C(nc)]= 0.0	[dXC(nc)]= 0.0	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
[nc]=71	[C(nc)]= 0.0	[dXC(nc)]= 0.0	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
[nc]=72	[C(nc)]= 0.0	[dXC(nc)]= 0.0	[dYC(nc)]= 0.0	[dZC(nc)]= 0.0
N200	*(DATA1 FOR B AXIS HEAD)*		(Tool length for DATA1)	[LTOOL_1]= 237.120
(LOCATION and SQUARENESS ERRORS)				
	[EA0B]= 0.0	[EC0B]= 0.0	[EX0B]= 0.0	[EZ0B]= 0.0
(index)	(B angle in degrees)	(X deviation)	(Y deviation)	(Z deviation)
N201				
[nb]=1	[B(nb)]= 0.0	[dXB(nb)]= 0.0	[dYB(nb)]= 0.0	[dZB(nb)]= 0.0
[nb]=2	[B(nb)]= 0.0	[dXB(nb)]= 0.0	[dYB(nb)]= 0.0	[dZB(nb)]= 0.0
[nb]=3	[B(nb)]= 0.0	[dXB(nb)]= 0.0	[dYB(nb)]= 0.0	[dZB(nb)]= 0.0
[nb]=35	[B(nb)]= 0.0	[dXB(nb)]= 0.0	[dYB(nb)]= 0.0	[dZB(nb)]= 0.0
[nb]=36	[B(nb)]= 0.0	[dXB(nb)]= 0.0	[dYB(nb)]= 0.0	[dZB(nb)]= 0.0
N300	*(DATA2 FOR B AXIS HEAD)*		(Tool length for DATA2)	[LTOOL_2]= 177.200
(index)	(B angle in degrees)	(X deviation)	(Y deviation)	(Z deviation)
N301				
[nb]=37	[B(nb)]= 0.0	[dXB(nb)]= 0.0	[dYB(nb)]= 0.0	[dZB(nb)]= 0.0

- The 4 cells of 5th row define the estimated values of the location and perpendicularity errors of rotary axis.
- The 3 cells of the next row are used to define the coordinate of the tool center position (TCP) when the turntable is in reference position (R0).
- From row N12 (N101), the 4 columns allow to write respectively the values of C angular positions and the respective XYZ deviations expressed in specified units.
- The rowsN85 and up (N201) define the measurement data of the swivel axis, N301 is intended for a second set of corrections.

4.5 Programming

VEComp Rotary requires:

- The definition of the kinematic structure.
- Choice between two sets of offsets.
- Definition of the files containing the errors values (see annex for file structure and example)

The syntax for activating VEComp Rotary is as below.

4.5.1 Activation

The following syntax will activate the compensation once the axes are homed.

```
G247 T.. EK. EF..
```

With:

G247	**G function of volumetric error compensation**
T	Code number of the kinematic structure the code number is that given by the macro RTCP (see a second annex).
EK	Number of the set of kinematic offsets (1 or 2). This is useful in case of multiple heads with different RTCP data.
ET	Number of the file containing the data measurements

4.5.2 Inhibition of VEComp Rotary

Once the compensation has been activated it is possible to suspend it by the following syntax.

```
G247 S0
```

This will suspend the compensation and gradually clears the offsets.

4.5.3 Re-Activation

To re-activate the compensation after a suspend.

```
G247 EK. S1
```

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5 Integration

5.1 Machine parameters

VEComp and VEComp Rotary require adjusting the machine parameters P58N1 (program stack size for channel) and P59.

As well, the data files being normally stored in protected zones P59 may have to be adjusted in consequence.

- The values extracted from the data files will be saved in dedicated segments of the NCK memory.
- VEComp is using segment n°1: P59 N0 (required value = 100 meaning 100 Kbytes)
- VEComp Rotary is using segment n°2 : P59 N1 (required value = 32 meaning 32 Kbytes)
- VEComp also uses symbolic variables, the required size of program stack (P58N1 expressed in Kbytes) can be determined according to the chart below; do not forget to add the size required for other applications.

Machine configuration	Size of data in the program stack
3 axis machine	35kbytes
4 axis machine	47kbytes
5 axis machine	58kbytes
5 axis machine with gantry axis	69kbytes
VEComp rotary	32kbytes

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A Appendix

A.1 List of E80xxx parameters (VEComp)

The address of the beginning of the E80xxx parameters area is customizable by the symbolic variable [E80xxx]. The default address of these symbolic variables starts at E80100.

[E80xxx]	Address of memory segment of data compensation
[E80xxx] + 1	Control word of enable location error compensation
[E80xxx] + 2	Control word of enable errors motion compensation
[E80xxx] + 3	Kinematic number
[E80xxx] + 4	Status of initializing of compensation table in memory segment
[E80xxx] + 5	Control word of enable X Y Z axis error motions
[E80xxx] + 6	Control word of enable W V U axis error motions
[E80xxx] + 7	Control word of enable C B A axis error motions
[E80xxx] + 8	Control word of enable Y2 X2 slave axis error motions
[E80xxx] + 9	Angular & linear deviation units: - tenth digit for linear deviation : 3: for mm 6: for 1µm - unit digit for angular deviation: 1: for rad 3 : for mm/m 6:for µm/m
[E80xxx] + 10	Word of axis addresses ordered by byte | byte3 addr of X2 | byte2 addr of Z | byte1 addr of Y | byte0 addr of X
[E80xxx] + 11	Word of axis addresses ordered by byte | byte3 addr of Y2 | byte2 addr of W | byte1 addr of V | byte0 addr of U
[E80xxx] + 12	Word of axis addresses |------------| byte2 addr of C | byte1 addr of B | byte0 addr of A
[E80xxx] + 13	CNC internal unit for lin/rot defined with 2 digits tenth digit for linear axis : 2 : for 10µm 3 : for 1µm 4 : for 100 nm 5 : for 10 nm unit digit for rotary axis : 3:for 1/1000 deg 4:for 1/10000deg
[E80xxx] + 14 to 25	Kinematic dimensions
[E80xxx] + 14 to 25	Kinematic dimensions
[E80xxx] + 26	Reserved control word
[E80xxx] + 27	Not used
[E80xxx] + 28	NC sample time in micro sec
[E80xxx] + 29	Max feed of acceleration & feed control loop used for compensation values expressed in mm/min
[E80xxx] + 30	Max acceleration of acceleration & feed control loop used for compensation. Value expressed in mm/s²

A.2 List of External E83x parameters (VEComp)

The address of the beginning of the E83xxx parameters area is customizable by the symbolic variable [E83xxx]. The default address starts to E83000.

[E83xxx]	Error number returned by VEComp
[E83xxx] + 1 and 2	Value and address of field tool corrector number in executed block, given from the classical dynamic operator 25 Oi=25 E83001/E83002/#RL#0 [/E mask/shift value] optional.
[E83xxx] + 3	Request to switch off the 3D errors compensation and to smoothly vanish the 3D offsets. E83_INHIBIT_REQ=1 when G246 S0 instruction is programmed.
[E83xxx] + 4	Quick watch of execution time
[E83xxx] + 5	Computed value of X axis error, expressed in mm
[E83xxx] + 6	Computed value of Y axis error, expressed in mm
[E83xxx] + 7	Computed value of Z axis error, expressed in mm
[E83xxx] + 8	X error compensation value after applying the dynamic constraints
[E83xxx] + 9	Y error compensation value after applying the dynamic constraints
[E83xxx] + 10	Z error compensation value after applying the dynamic constraints

A.3 E80x parameters used by RTCP and Inclined plane (VEComp)

The RTCP function uses a series of 25 E Parameters for saving the current context of RTCP internal calculated variables. The backup address begins at E80170 but can be customized by the machine manufacturer.

E80170 to E80194	Reserved by the RTCP function in case of an usual customization. (see the customization program %10151.9)

The inclined plane function uses 4 E parameters. The default addresses are:

E80196	Used to save the current type of 5 axis kinematic.
E80197	Used to define the coordinate system of the inclined plane function.
E80198	Containing the position measurement of the rotary axis and according to the type of the R rotary axis measurement.
E80199	Containing the position measurement of the swivel axis and according to the type of the S swivel axis measurement.

A.4 Kinematic structures managed by VEComp

This list is not exhaustive and may evolve with the versions of VEComp.

3 axes configurations	Kinematic code number
w b X Y Z {C1} spindle t	1
w X b Y Z {C1} spindle t	2
w Y X b Z {C1} spindle t	3
w X Y b Z {C1} spindle t	4
w b Y X Z {C1} spindle t	5

4 axes configurations	Kinematic code number
w X b W Y Z {C1} spindle t	10
w b X1 X2 Y Z {C1} spindle t	11
w b Y1 Y2 X Z {C1} spindle t	12
w C v X Y Z {C1} spindle t	13
w C X b Y Z {C1} spindle t	14
w b X Y Z C {B1} spindle t	15
w B Z b X Y {C1} spindle t	16
w B X Z b Y {C1} spindle t	17

5 axes configurations	Kinematic code number
w X b Y Z B A {C1} spindle t	28
w X b Y Z A B {C1} spindle t	29
w b X Y Z C A {C1} spindle t	30
w b X Y Z C B {C1} spindle t	31
w b X Y Z B A {C1} spindle t	32
w b X Y Z A B {C1} spindle t	33
w X b Y Z C A {C1} spindle t	34
w X b Y Z C B {C1} spindle t	35
w C X b Y Z A {C1} spindle t	36
w C X b Y Z B {C1} spindle t	37
w C b X Y Z A {C1} spindle t	38
w B b X Y Z A {C1} spindle t	39
w C A b X Y Z {C1} spindle t	40
w C B b X Y Z {C1} spindle t	41
w B C b X Y Z {C1} spindle t	42
w B A b X Y Z {C1} spindle t	43

w A C b X Y Z {C1} spindle t	44
w A B b X Y Z {C1} spindle t	45
w C b X Y Z B {C1} spindle t	46
w A b X Y Z B {C1} spindle t	47
w B A X b Y Z {C1} spindle t	48
w C b Y Z X B {C1} spindle t	49
w B A Z b X Y {C1} spindle t	50
w C B b Y X Z {C1} spindle t	51
w C A Y b X Z {C1} spindle t	52
w C A X Z b Y {C1} spindle t	53
w C Y X b Z B {C1} spindle t	54
w C A X b Y Z {C1} spindle t	55

5 axes configurations gantry drives	Kinematic code number
w b X1 X2 Y Z C A {C1} spindle t	70
w b X1 X2 Y Z C B {C1} spindle t	71
w b X1 X2 Y Z B A {C1} spindle t	72
w b X1 X2 Y Z A B {C1} spindle t	73
w b Y1 Y2 X Z C A {C1} spindle t	74
w b Y1 Y2 X Z C B {C1} spindle t	75

A.5 List of E80xxx parameters (VEComp Rotary)

The address of the beginning of the E80xxx parameters area is customizable by symbolic variable [E80xxx]. The default address of these symbolic variables starts at E80150.

[E80xxx]	Address of memory segment of data compensation
[E80xxx] + 1	Control word for enabling the location error compensation
[E80xxx] + 2	Control word for enabling the 3D deviations compensation
[E80xxx] + 3	Code number of rotary kinematic chain (RTCP kinematic type)
[E80xxx] + 4	Status of initializing of compensation table in memory segment
[E80xxx] + 5	Angular & linear deviation units: - tenth digit for linear deviation : 3: for mm 6 : for 1µm - unit digit for angular deviation: 1: for rad 3 :f or mm/m 6 : for µm/m
[E80xxx] + 6	CNC internal unit for lin/rot defined with 2 digits tenth digit for linear axis : 2 : for 10µm 3 : for 1µm 4 : for 100 nm 5 : for 10 nm unit digit for rotary axis : 3 : for 1/1000 degree 4 : for 1/10000 degree
[E80xxx] + 7	Control word of enabling Data deviations of C B A axis
[E80xxx] + 8	Max speed of error compensation in mm/min
[E80xxx] + 9	NC sample time in micro sec
[E80xxx] + 10	Word of axis addresses ordered by byte |byte3 address of X2|byte2 addrZ|byte1 addrY|byte0 addrX
[E80xxx] + 11	Word of axis addresses ordered by byte |byte3 addrY2|byte2 addrW|byte1 addrV|byte0 addrU
[E80xxx] + 12	Word of axis addresses ordered by byte |------------|byte2 addrC|byte1 addrB|byte0 addrA
[E80xxx] + 13 to 24	Kinematic dimensions: - offsets of rotary axis xr/yr/zr along x,y,z direction and expression in mm - offsets of swivel axis xs/ys/zs - Ix Jy Kz tool unit vector - x4 y4 z4 offsets between two spindle noozes
[E80xxx] + 25 to 26	RLimit and ZLimit for array bounds
[E80xxx] + 27	Max accel of error compensation in mm/s^2

A.6 List of External E83x parameters (VEComp Rotary)

The address of the beginning of the E83xxx parameters area is customizable by symbolic variable [E83xxx]. The default address can begin at E83000 (i.e [E83xxx]=83000).

[E83xxx]	Error number returned by VEComp
[E83xxx] + 1 and 2	Tool correction value of field
[E83xxx] + 3	Request to switch off the rotary deviation compensation and to smoothly vanish the 3D offsets. E83_INHIBIT_REQ=1 when G247 S0 instruction is programmed.
[E83xxx] + 4	Quick watch of execution time
[E83xxx] + 5	Computed value of X axis error, expressed in mm
[E83xxx] + 6	Computed value of Y axis error, expressed in mm
[E83xxx] + 7	Computed value of Z axis error, expressed in mm

A.7 Kinematic structures managed by VEComp Rotary

This list is not exhaustive and may evolve with the versions of VEComp.

kin n°01	DUAL TWIST HEAD A ON B
kin n°02	DUAL TWIST HEAD A ON C
kin n°03	DUAL TWIST HEAD B ON A
kin n°04	DUAL TWIST HEAD B ON C
kin n°05	NUTATING ROTARY HEAD TILTED A ON B
kin n°06	NUTATING ROTARY HEAD TILTED A ON C
kin n°07	NUTATING ROTARY HEAD TILTED B ON C
kin n°08	NUTATING ROTARY HEAD B ON TILTED A
kin n°09	B ROTARY TABLE & A AXIS HEAD
kin n°10	C ROTARY TABLE & A AXIS HEAD
kin n°11	A ROTARY TABLE & B AXIS HEAD
kin n°12	C ROTARY TABLE & B AXIS HEAD
kin n°13	TILTING ROTARY TABLES A ON B
kin n°14	TILTING ROTARY TABLES A ON C
kin n°15	TILTING ROTARY TABLES B ON A
kin n°16	TILTING ROTARY TABLES B ON C
kin n°17	TILTING ROTARY TABLES C ON A
kin n°18	TILTING ROTARY TABLES C ON B
kin n°19	SWIVEL A AXIS HEAD
kin n°20	SWIVEL B AXIS HEAD
kin n°21	A ROTARY TABLE
kin n°22	B ROTARY TABLE
kin n°23	C ROTARY TABLE

A.8 List of errors of VEComp system

The VEComp messages are in the range 700 - 703 with the following extension.

700	Extension	Configuration Error
	1	Invalid option 99 or 100 needed for VEComp
	2	Invalid option 99 needed for ROTARY VEComp
	3	Data Segment is probably not initialized

A.8.1 Errors relative to the NC macro files

701	Extension	VEComp Programming Error
	1	Invalid value of T argument to specify the machine kinematic
	2	Inconsistency between T argument and numbers of data files
	3	Key words no found in the machine kinematic structure
	4	Deviation symbol missing in the X error motions file passed by EX arg.
	5	Deviation symbol missing in the Y error motions file passed by EY arg.
	6	Deviation symbol missing in the Z error motions file passed by EZ arg.
	7	Deviation symbol missing in the U error motions file passed by EU arg.
	8	Deviation symbol missing in V error motions file passed by EV arg.
	9	Deviation symbol missing in W error motions file passed by EW arg.
	10	Deviation symbol missing in A error motions file passed by EA arg.
	11	Deviation symbol missing in B error motions file passed by EB arg.
	12	Deviation symbol missing in C error motions file passed by EC arg.
	13	Deviation symbol missing in X2 error motions file passed by ER arg.
	14	Deviation symbol missing in Y2 error motions file passed by ES arg.
	15	Inconsistency between the location & orientation error file and the kinematic structure
	16	Incorrect value of ET arg. giving the spindle axis direction
	17	Internal unit unprocessed by VEComp function
	18	Incorrect unit of linear deviations
	19	Incorrect unit of angular deviations
	20	Inconsistency between X axis address and the deviation data file
	21	Inconsistency between Y axis address and the deviation data file
	22	Inconsistency between Z axis address and the deviation data file
	23	Inconsistency between U axis address and the deviation data file
	24	Inconsistency between V axis address and the deviation data file
	25	Inconsistency between W axis address and the deviation data file
	26	Inconsistency between A axis address and the deviation data file
	27	Inconsistency between B axis address and the deviation data file
	28	Inconsistency between C axis address and the deviation data file
	29	Inconsistency between X2 slave axis address and the deviation data file
	30	Inconsistency between Y2 slave axis address and the deviation data file
	31	Inhomogeneous unit of linear deviations between data files
	32	Inhomogeneous unit of angular deviations between data files

A.8.2 Errors at initialization of G246 function

702	Extension	VEComp Programming Error
	1	Invalid address of DRAM segment
	2	Invalid address of sub data segment
	3	Kinematic number no found or kinematic model not handled by VEComp
	4	Reading error in DRAM segment
	5	Kinematic code number not found in data segment
	6	Internal unit unprocessed by VEComp function
	7	Unassigned pointer in routine of spatial errors computation
	8	Null pointer in routine of DRAM copy
	9	A compensated position coordinate exceeds the axis stroke limits
	10	Wrong size of the X axis error motion tables
	11	Wrong size of the Y axis error motion tables
	12	Wrong size of the Z axis error motion tables
	13	Wrong size of the U axis error motion tables
	14	Wrong size of the V axis error motion tables
	15	Wrong size of the W axis error motion tables
	16	Wrong size of the A axis error motion tables
	17	Wrong size of the B axis error motion tables
	18	Wrong size of the C axis error motion tables
	19	Wrong size of the X2 axis error motion tables
	20	Wrong size of the Y2 axis error motion tables
	21	Invalid option 99 by redundant checking
	22	Invalid option 100 by redundant checking
	23	Sorting failure of X2 axis error motion tables
	24	Sorting failure of Y2 axis error motion tables
	25	Sorting failure of X axis error motion tables
	26	Sorting failure of Y axis error motion tables
	27	Sorting failure of Z axis error motion tables
	28	Sorting failure of U axis error motion tables
	29	Sorting failure of V axis error motion tables
	30	Sorting failure of W axis error motion tables
	31	Sorting failure of A axis error motion tables
	32	Sorting failure of B axis error motion tables
	33	Sorting failure of C axis error motion tables
	34	Incorrect unit of linear deviations

702	35	Incorrect unit of angular deviations
	36	Null pointer : fct clear error motions
	37	Null pointer : fct clear location errors

A.8.3 Errors during execution

703	**Extension**	**VEComp Error in the RTS task**
	1	Out of range of state filter
	2	Out of range of state filter in initialization step
	3	Computed exceeding of stroke limits of X axis
	4	Computed exceeding of stroke limits of Y axis
	5	Computed exceeding of stroke limits of Z axis
	6	Unassigned pointer in routine of spatial errors computation
	7	Unable to compute a weighted compensation of spatial errors for the gantry

A.9 List of errors of VEComp Rotary system

The VEComp Rotary messages are in the common range 700 and the range 704-707 with the following extension.

700	Extension	Configuration Error
	1	Invalid option 99 or 100 needed for VEComp
	2	Invalid option 99 needed for ROTARY VEComp
	3	Data Segment is probably not initialized

A.9.1 Errors relative to the NC macro files G247

704	Extension	VEComp Rotary Programming Error
	1	Invalid value of T argument to specify the machine kinematic
	2	Kinematic number T no found or kinenatic model not handled by ROTARY VEComp
	3	Invalid set of kinematic dimensions EK
	4	Invalid file number of deviations EF
	5	Not used
	6	Inconsistency between A axis address and the deviation data file
	7	Inconsistency between A axis address and the deviation data file
	8	Inconsistency between A axis address and the deviation data file

A.9.2 Errors at initialization of G247 function

705	Extension	VEComp Rotary Error at initializing process
	1	Invalid address of DRAM Segment Sn
	2	Invalid address of Data sub-Segment
	3	Data Segment is empty
	4	The size of used segment is not that allocated to the kinematic object
	5	Kinematic number no found or kinematic model not handled by VEComp Rotary
	6	Reading error in DRAM segment
	7	Kinematic code number not found in data segment
	8	Internal unit unprocessed by VEComp Rotary function
	9	Invalid option 99 by redundant checking
	10	Null pointer in routine of DRAM copy
	11	Sorting failure of data arrays of dual axes : invalid address
	12	Sorting failure of data arrays of the swivel head: invalid address
	13	Sorting failure of data arrays of the rotary table: invalid address
	14	Sorting failure: wrong size of a data array
	15	Sorting failure: invalid address of one of data arrays
	16	Sorting failure: invalid type of kinematic chain
	17	Not used
	18	Size of data array is out of range : 180 maxi
	19	Size of data array is out of range : 72 maxi
	20	Size of data array is out of range : 36 maxi
	21	Incorrect unit of linear deviations
	22	Incorrect unit of angular deviations

A.9.3 Errors during execution

706	Extension	VEComp Error in the RTS task
	1	Unassigned pointer in routine of Cartesian errors computation
	2	Computed exceeding of stroke limits of X axis
	3	Computed exceeding of stroke limits of Y axis
	4	Computed exceeding of stroke limits of Z axis

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Published by NUM Spa

Via F. Somma 62
20012 Cuggiono (MI) (Italy)
Tel. : +39 02 979 691
website: www.num.com

Printed April 2016

CNC HighEnd Applications