DZHK
DEUTSCHES ZENTRUM FÜR
HERZ-KREISLAUF-FORSCHUNG E.V.

DZHK-SOP-K-06

Cardiac magnetic resonance imaging

Version: V1.0 Effective date: 01/09/2014

Replaces version: - Dated: -

Change note: -

	Technical author	**Technical reviewer**	**Approval of Department Head**	**Approval DZHK**
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Date	26/08/2014		26/08/2014	26/08/2014
Signature				

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1 INTRODUCTION

1.1 LIST OF ABBREVIATIONS

Abbreviation	Plain text
AV grooves	Atrioventricular grooves
ECG/EKG	Electrocardiogram
LV mass/BSA	Indexed left ventricular mass
LVEDD	Left ventricular end-diastolic diameter
LV-EDVI	Left ventricular end-diastolic volume index
LV-EF	Left ventricular ejection fraction
LVESD	Left ventricular end-systolic diameter
LV-SVI	Left ventricular stroke volume index
MRI	Magnetic resonance imaging
RV-EDVI	Right ventricular end-diastolic volume index
RV-EF	Right ventricular ejection fraction
RV-ESVI	Right ventricular end-systolic volume index
RV-SVI	Right ventricular stroke volume index

1.2 OBJECTIVE

The aim of the modules presented in this SOP is to ensure comparability of the protocols across all locations. Due to technical advances, the SOPs are continually updated. Furthermore, the aim is to continuously expand the modules within the scope of the study-specific questions.

The current version is based on the guidelines of the Society for Cardiovascular Magnetic Resonance (Kramer CM et al. Journal of Cardiovascular Magnetic Resonance 2008, 10:35 and Journal of Cardiovascular Magnetic Resonance 2013, 15:91).

1.3 TARGET GROUP

The MRI SOPs shall apply to all DZHK studies that involve cardiac magnetic resonance imaging.

1.3.1 Inclusion criteria

The inclusion criteria are stipulated in the study protocol of the planned studies.

1.3.2 Exclusion criteria

Contraindications:

Pacemakers, defibrillators

- Neurostimulators
- Metal vascular clips
- Cochlear implants
- Ferromagnetic intravascular filters and shunts that were implanted less than 1 month ago
- Starr-Edwards prosthetic heart valves (old type of heart valve made of metal, implanted prior to 1970)
- Recently implanted ferromagnetic vascular clips
- Implanted permanent magnets (magnetic dentures)
- Implanted insulin or pain pumps
- Recently implanted joint replacement, magnetic resonance imaging is safe with titanium prostheses or joint replacements that were implanted a while ago
- Shrapnel

1.4 APPLICATION AND TASKS

Cardiac magnetic resonance imaging is a non-invasive standard procedure used in cardiac diagnostics.

1.5 TERMS AND DEFINITIONS

None

1.6 RELATIONSHIPS TO OTHER EXAMINATIONS

None

1.7 QUALITY LEVEL

This SOP corresponds to quality level 2.

DZHK quality level	
Performance	
Level 1	Performance of the examination taking into account the guidelines of the specialist associations.
Level 2	Performance of the examination according to the provisions of the DZHK-SOP. This SOP defines minimum requirements for the quality of the performance and qualification of the examiner.
Level 3	Performance of the examination according to the provisions of the DZHK-SOP and certification of the examiners: Definition of intra- and interobserver variability (standard of epidemiological studies).

2 PREREQUISITES OF THE EXAMINATION

Take into consideration all factors to ensure the examination.

2.1 REQUIREMENTS REGARDING ROOMS/EQUIPMENT

According to the provisions of the respective institutions for performing magnetic resonance imaging procedures.

2.2 DEVICES/HARDWARE

- ECG/EKG
- Ear protectors
- MRI/examination coil
- Contrast agent injector

2.3 SPECIAL CLINICAL CONSUMABLES

- Venous access

2.4 ESSENTIAL DOCUMENTS

Informed Consent Form (completed in full)

Check of laboratory values (e.g. creatinine or GFR)

2.5 ESSENTIAL INFORMATION

Review contraindications (implants, etc.)

e.g. date, patient ID, etc.

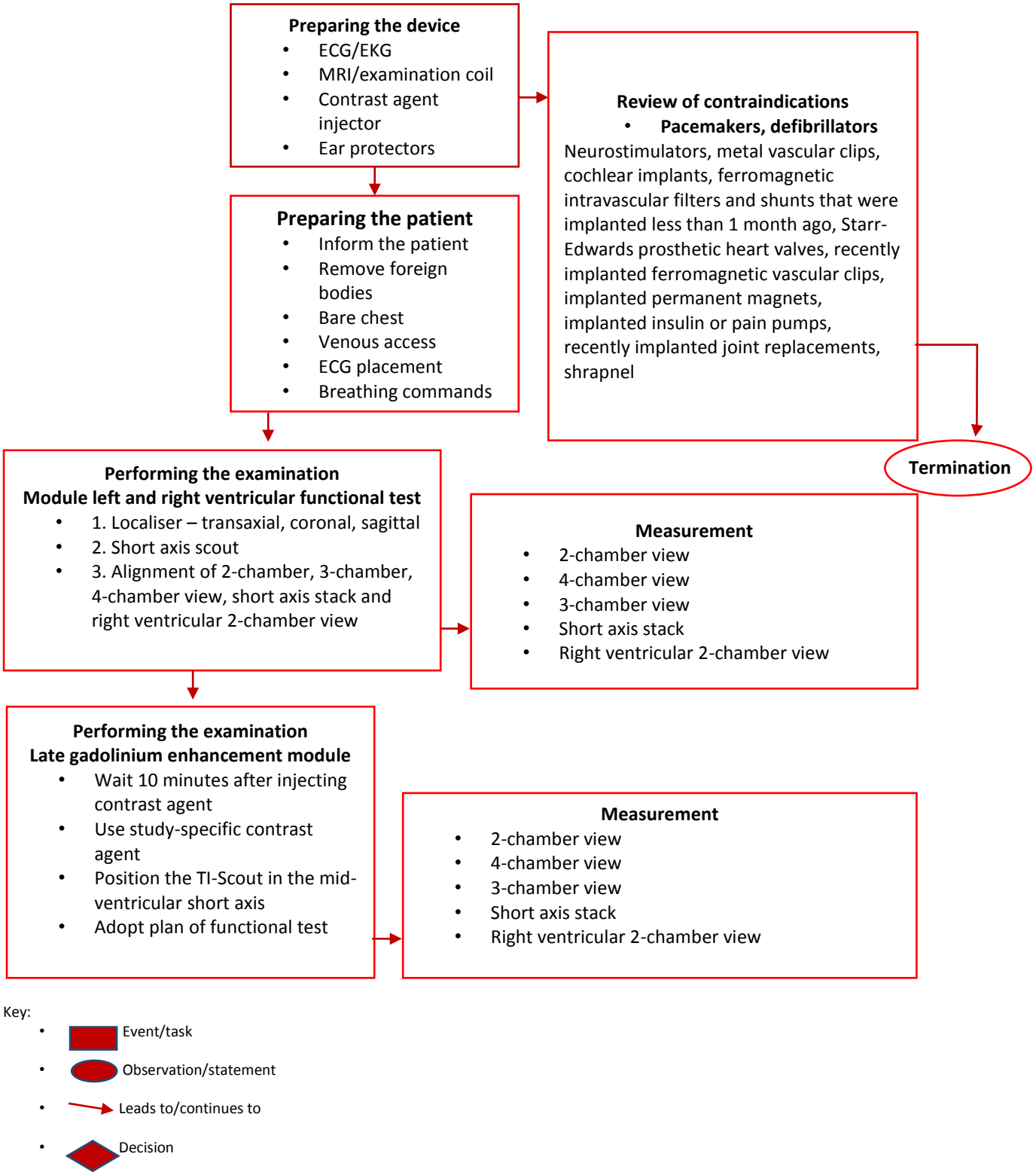
2.6 PERSONNEL

The prerequisites for implementing this SOP and involved personnel include:

- Medical technical assistants
- Physicians

3 IMPLEMENTATION/WORKFLOW/WORK STEPS

3.1 FLOWCHART OF THE PROCEDURE



3.2 PREPARING FOR THE EXAMINATION

- Check the Informed Consent Form
- Check the laboratory values (creatinine)
- Ask about height and weight

3.2.1 Preparing the workplace

None

3.2.2 Preparing the devices

- Position and insert the coil, prepare the positioning aids
- Prepare and connect the contrast agent injector

3.2.3 Principles of preparing the subject for the examination

- Inform the patient about the course of the examination
- Remove all foreign bodies (e.g. jewellery, ECG cables, etc.) and clothing (e.g. bra, zips, metal buttons, metal threads, etc.), and any dental prosthesis that interfere with the examination
- Ask the patient to strip down to the waist, surgical shirt (opening in front) or facility-internal clothing
- If necessary, prepare the venous access
- Place the ECG, additional monitoring depending on the planned examination
- Explain the breathing commands
- Apply ear protectors

Positioning the patient

- Supine position, head first
- Apply the cardiac coil or the manufacturer-specific surface coil
- Lay arms alongside the body
- Ear protectors
- Make the patient as comfortable as possible using positioning aids
- If necessary, connect the patient to the contrast agent injector

3.3 PERFORMING THE EXAMINATION

Module left and right ventricular functional test *

***prior to commencing every study, details are adjusted according to current knowledge, during each study the parameters are kept constant; furthermore, manufacturer-independent "generic" protocols are generated that define the details of the sequences.*

1. Localiser in all 3 patient axes (transaxial, coronal, sagittal)

2. Short axis scout

3. Alignment and measurement of 2-chamber, 3-chamber, 4-chamber view, short axis stack, right ventricular 2-chamber view

Manual alignment is outlined below; however, automatic algorithms such as the three-point method can also be applied.

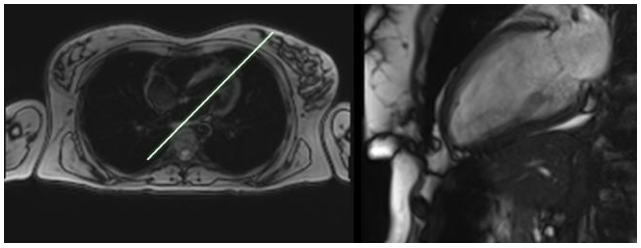


Figure 1: 2-chamber view

2-chamber view

The 2-chamber view is aligned on the axial localiser through the centre of the mitral valve and the tip of the left ventricle.

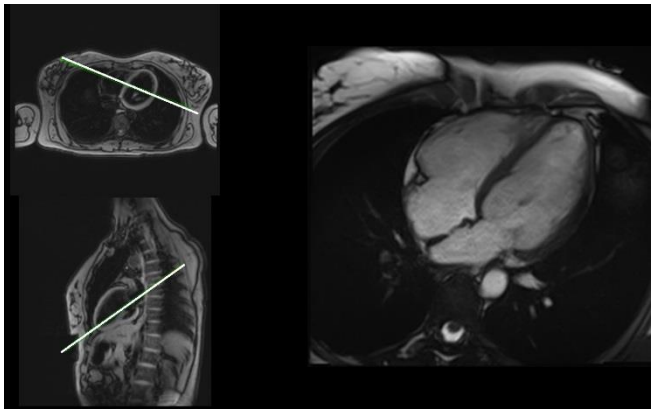


Figure 2: 4-chamber view

4-chamber view

The 4-chamber view is aligned on the short axis localiser and also using the 2-chamber view, whereby it must be ensured that the alignment runs through the tip of the 2-chamber view and verified on the short axis localiser that the left ventricular outflow tract is not included on the image.

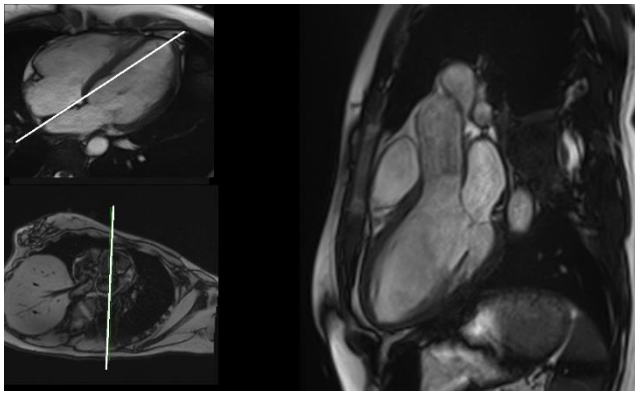


Figure 3: 3-chamber view

3-chamber view

The 3-chamber view is aligned from the 4-chamber view and the short axis localiser. A cross-section through the left ventricular outflow tract is chosen on the short axis stack, whereby for the 4-chamber view it must be ensured that the cross-section runs through the apex of the heart.

The 3-chamber view is needed for assessing anteroseptal and inferolateral wall motion disorders. Furthermore, it can be used to determine the thickness of the basal anterior septum (basal septum) and of the inferior lateral wall (basal lateral wall). In addition, the left ventricular end-diastolic (LVEDD) and end-systolic (LVESD) diameter, the diameter of the left atrium and the diameter of the left ventricular outflow

tract (LVOT) can be measured in the 3-chamber view.

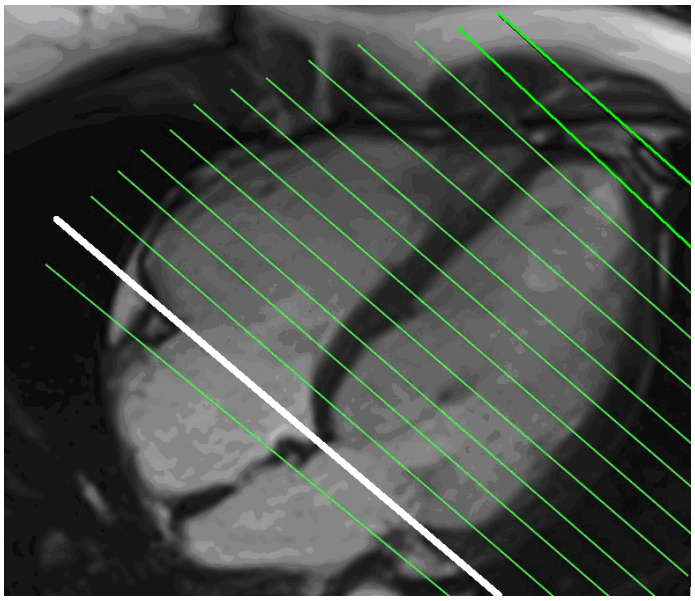


Figure 4: Short axis stack

Short axis stack

The short axis stack is aligned in diastole. The first layer should be located inside the left atrium and the last layer outside the left ventricle. The short axis stack is aligned such that a connection between the AV grooves (white line) can be created at the height of the mitral and tricuspid valve. The remaining short axes cover the entire left and right ventricle up to the apex of the heart and are parallel to the initial short axis.

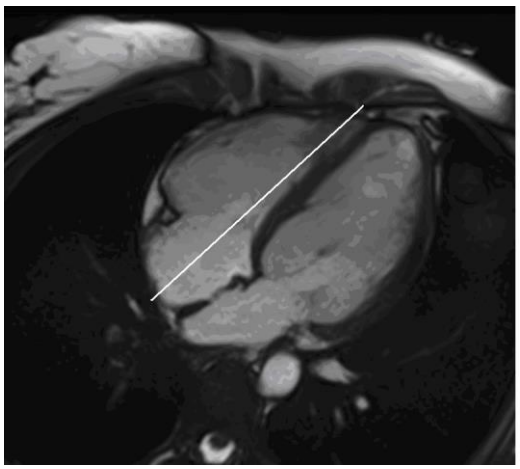


Figure 5: Right ventricular 2-chamber view

Right ventricular 2-chamber view

In addition, a longitudinal section through the right ventricle should be made.

Late gadolinium enhancement module *

***prior to commencing every study, details are adjusted according to current knowledge, during each study the parameters are kept constant; furthermore, manufacturer-independent "generic" protocols are generated that define the details of the sequences.*

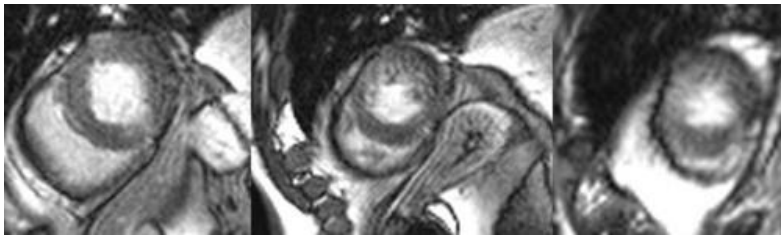


Figure 6: Late gadolinium enhancement module

- Wait 10 minutes after injecting the contrast agent.
- The contrast agent to be used (volume and type depending on relaxivity) are defined specifically for each study. The injection rate (flow rate) is also adjusted accordingly.
- TI-Scout to determine the zero-crossing point of the signal of the healthy myocardium. Position the TI-Scout in the mid-ventricular short axis.

- Recording of the late gadolinium enhancement images of all short axes, of the 2 left and right ventricular 2-chamber views, of the 3-chamber view and of the 4-chamber view (in doing so, the alignment should correspond to that of the functional test).

3.4 FOLLOW-UP AND DATA COLLECTION

Evaluation of the MRI images using the respective evaluation software

3.5 PROCEDURE IN CASE OF DEVIATIONS

None

4 LITERATURE AND REFERENCES

Kramer CM et al. Journal of Cardiovascular Magnetic Resonance 2008, 10:35

Kramer CM et al. Journal of Cardiovascular Magnetic Resonance 2013, 15:91

5 CHANGE

Change compared to the previous version

Section	Description of the change to the previous version
2.1	
2.2	
2.3	
….	

6 PERSONS INVOLVED

Name	**Role**	**Involvement**
PD Dr. Christina Dösch	Initial author	Creation of SOP
Dr. Christian Liebetrau	Author	Technical review
Prof. Dr. Joachim Lotz	Author	Technical review
PD Dr. Rolf Wachter	Author	Technical review
Prof. Dr. Jeanette Schulz-Menger	Last author	Technical review

7 ANNEXES

7.1 ECRF MODULE

MRT

Examination details

I.	Was the MRI performed?*	○ yes ○ no ○ unknown ○ not assessed	Kommentar Query
II.	Date of examination*	☑ [ ] - [ ] - [ ] tt.mm.jjjj	Kommentar Query
III.	Quality level*	< Bitte auswählen >	Hilfe Kommentar Query

1. Cine 4-chamber view

1.1.	Diameter of the right ventricle*	☑ [ ] mm	Kommentar Query
1.2.	Diameter of the right atrium*	☑ [ ] mm	Kommentar Query
1.3.	MAPSE*	☑ [ ] mm	Kommentar Query
1.4.	TAPSE*	☑ [ ] mm	Kommentar Query
1.5.	Maximum left atrial area*	☑ [ ] cm²	Kommentar Query
1.6.	Minimum left atrial area*	☑ [ ] cm²	Kommentar Query
1.7.	Maximum length of the axis of the left atrium*	☑ [ ] mm	Kommentar Query
1.8.	Minimum length of the axis of the left atrium*	☑ [ ] mm	Kommentar Query

2. Cine 2-chamber view

2.1.	Maximum left atrial area*	☑ [ ] cm²	Kommentar Query
2.2.	Minimum left atrial area*	☑ [ ] cm²	Kommentar Query
2.3.	Maximum length of the axis of the left atrium*	☑ [ ] mm	Kommentar Query
2.4.	Minimum length of the axis of the left atrium*	☑ [ ] mm	Kommentar Query

3. *Short-axis multislice cine*			
3.1.	Basal septum*	☑ mm	Kommentar Query
3.2.	Basal lateral wall*	☑ mm	Kommentar Query
3.3.	Left ventricular end-diastolic diameter (LVEDD)*	☑ mm	Kommentar Query
3.4.	Left ventricular end-systolic diameter (LVESD)*	☑ mm	Kommentar Query
3.5.	Left ventricular ejection fraction (LV-EF)*	☑ %	Kommentar Query
3.6.	Left ventricular end-diastolic volume index (LV-EDVI)*	☑ ml/m²	Kommentar Query
3.7.	Left ventricular end-systolic volume index (LV-ESVI)*	☑ ml/m²	Kommentar Query
3.8.	Left ventricular stroke volume index (LV-SVI)*	☑ ml/m²	Kommentar Query
3.9.	Indexed left ventricular mass (LV mass/body surface)*	☑ g/m²	Kommentar Query
3.10.	Right ventricular ejection fraction (RV-EF)*	☑ %	Kommentar Query
3.11.	Right ventricular end-diastolic volume index (RV-EDVI)*	☑ ml/m²	Kommentar Query
3.12.	Right ventricular end-systolic volume index (RV-ESVI)*	☑ ml/m²	Kommentar Query
3.13.	Right ventricular stroke volume index (RV-SVI)*	☑ ml/m²	Kommentar Query
4. *Examination details (Late Gadolinium Enhancement (LGE))*			
4.1.	LGE in AHA 17-segment model infarction-typical*	○ yes ○ no ○ unknown ○ not assessed	Kommentar Query

7.2 LIST OF FIGURES

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DZHK-SOP-K-06

Kardiale Magnetresonanztomographie

Version: V1.0 Gültig ab: 01.09.2014

Ersetzte Version: Vom:

Änderungshinweis:

	Fachlicher Autor	Fachlicher Review	Zustimmung Bereichsleitung	Freigabe DZHK
Name	C. Dösch (Mannheim) C. Liebetrau (Bad Nauheim) J. Lotz (Göttingen) R. Wachter (Göttingen) J. Schulz-Menger (Berlin)		Matthias Nauck	Thomas Eschenhagen
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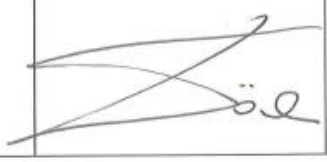
Unterschrift				

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