# NAG Library Function Document

# nag_dormrz (f08bkc)

## 1 Purpose

nag_dormrz (f08bkc) multiplies a general real $m$ by $n$ matrix $C$ by the real orthogonal matrix $Z$ from an $RZ$ factorization computed by nag_dtzrzf (f08bhc).

## 2 Specification

```
#include <nag.h>
#include <nagf08.h>

void nag_dormrz (Nag_OrderType order, Nag_SideType side,
    Nag_TransType trans, Integer m, Integer n, Integer k, Integer l,
    const double a[], Integer pda, const double tau[], double c[],
    Integer pdc, NagError *fail)
```

## 3 Description

nag_dormrz (f08bkc) is intended to be used following a call to nag_dtzrzf (f08bhc), which performs an $RZ$ factorization of a real upper trapezoidal matrix $A$ and represents the orthogonal matrix $Z$ as a product of elementary reflectors.

This function may be used to form one of the matrix products

$$ZC, \quad Z^T C, \quad CZ, \quad CZ^T,$$

overwriting the result on $C$, which may be any real rectangular $m$ by $n$ matrix.

## 4 References

Anderson E, Bai Z, Bischof C, Blackford S, Demmel J, Dongarra J J, Du Croz J J, Greenbaum A, Hammarling S, McKenney A and Sorensen D (1999) *LAPACK Users' Guide* (3rd Edition) SIAM, Philadelphia http://www.netlib.org/lapack/lug

## 5 Arguments

1:  **order** – Nag_OrderType                                                                    *Input*

   *On entry*: the **order** argument specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = Nag_RowMajor. See Section 3.2.1.3 in the Essential Introduction for a more detailed explanation of the use of this argument.

   *Constraint*: **order** = Nag_RowMajor or Nag_ColMajor.

2:  **side** – Nag_SideType                                                                       *Input*

   *On entry*: indicates how $Z$ or $Z^T$ is to be applied to $C$.

   **side** = Nag_LeftSide
      $Z$ or $Z^T$ is applied to $C$ from the left.

   **side** = Nag_RightSide
      $Z$ or $Z^T$ is applied to $C$ from the right.

   *Constraint*: **side** = Nag_LeftSide or Nag_RightSide.

3: **trans** – Nag_TransType *Input*

*On entry*: indicates whether $Z$ or $Z^{\mathrm{T}}$ is to be applied to $C$.

**trans** $=$ Nag_NoTrans
    $Z$ is applied to $C$.

**trans** $=$ Nag_Trans
    $Z^{\mathrm{T}}$ is applied to $C$.

*Constraint*: **trans** $=$ Nag_NoTrans or Nag_Trans.

4: **m** – Integer *Input*

*On entry*: $m$, the number of rows of the matrix $C$.

*Constraint*: $\mathbf{m} \geq 0$.

5: **n** – Integer *Input*

*On entry*: $n$, the number of columns of the matrix $C$.

*Constraint*: $\mathbf{n} \geq 0$.

6: **k** – Integer *Input*

*On entry*: $k$, the number of elementary reflectors whose product defines the matrix $Z$.

*Constraints*:

    if **side** $=$ Nag_LeftSide, $\mathbf{m} \geq \mathbf{k} \geq 0$;
    if **side** $=$ Nag_RightSide, $\mathbf{n} \geq \mathbf{k} \geq 0$.

7: **l** – Integer *Input*

*On entry*: $l$, the number of columns of the matrix $A$ containing the meaningful part of the Householder reflectors.

*Constraints*:

    if **side** $=$ Nag_LeftSide, $\mathbf{m} \geq \mathbf{l} \geq 0$;
    if **side** $=$ Nag_RightSide, $\mathbf{n} \geq \mathbf{l} \geq 0$.

8: **a**$[dim]$ – const double *Input*

**Note**: the dimension, *dim*, of the array **a** must be at least

    $\max(1, \mathbf{pda} \times \mathbf{m})$ when **side** $=$ Nag_LeftSide and **order** $=$ Nag_ColMajor;
    $\max(1, \mathbf{k} \times \mathbf{pda})$ when **side** $=$ Nag_LeftSide and **order** $=$ Nag_RowMajor;
    $\max(1, \mathbf{pda} \times \mathbf{n})$ when **side** $=$ Nag_RightSide and **order** $=$ Nag_ColMajor;
    $\max(1, \mathbf{k} \times \mathbf{pda})$ when **side** $=$ Nag_RightSide and **order** $=$ Nag_RowMajor.

The $(i, j)$th element of the matrix $A$ is stored in

    $\mathbf{a}[(j - 1) \times \mathbf{pda} + i - 1]$ when **order** $=$ Nag_ColMajor;
    $\mathbf{a}[(i - 1) \times \mathbf{pda} + j - 1]$ when **order** $=$ Nag_RowMajor.

*On entry*: the $i$th row of **a** must contain the vector which defines the elementary reflector $H_i$, for $i = 1, 2, \ldots, k$, as returned by nag_dtzrzf (f08bhc).

9: **pda** – Integer *Input*

*On entry*: the stride separating row or column elements (depending on the value of **order**) in the array **a**.

*Constraints*:

> if **order** = Nag_ColMajor, **pda** $\geq$ max(1, **k**);
> if **order** = Nag_RowMajor,
>
> > if **side** = Nag_LeftSide, **pda** $\geq$ max(1, **m**);
> > if **side** = Nag_RightSide, **pda** $\geq$ max(1, **n**)..

10:   **tau**[*dim*] – const double                                                               *Input*

**Note**: the dimension, *dim*, of the array **tau** must be at least max(1, **k**).

*On entry*: **tau**[$i-1$] must contain the scalar factor of the elementary reflector $H_i$, as returned by nag_dtzrzf (f08bhc).

11:   **c**[*dim*] – double                                                                 *Input/Output*

**Note**: the dimension, *dim*, of the array **c** must be at least

> max(1, **pdc** $\times$ **n**) when **order** = Nag_ColMajor;
> max(1, **m** $\times$ **pdc**) when **order** = Nag_RowMajor.

The $(i, j)$th element of the matrix $C$ is stored in

> **c**[$(j-1) \times$ **pdc** $+ i - 1$] when **order** = Nag_ColMajor;
> **c**[$(i-1) \times$ **pdc** $+ j - 1$] when **order** = Nag_RowMajor.

*On entry*: the $m$ by $n$ matrix $C$.

*On exit*: **c** is overwritten by $ZC$ or $Z^{\mathrm{T}}C$ or $CZ$ or $Z^{\mathrm{T}}C$ as specified by **side** and **trans**.

12:   **pdc** – Integer                                                                        *Input*

*On entry*: the stride separating row or column elements (depending on the value of **order**) in the array **c**.

*Constraints*:

> if **order** = Nag_ColMajor, **pdc** $\geq$ max(1, **m**);
> if **order** = Nag_RowMajor, **pdc** $\geq$ max(1, **n**).

13:   **fail** – NagError *                                                                 *Input/Output*

The NAG error argument (see Section 3.6 in the Essential Introduction).

## 6   Error Indicators and Warnings

**NE_ALLOC_FAIL**

Dynamic memory allocation failed.

**NE_BAD_PARAM**

On entry, argument $\langle value \rangle$ had an illegal value.

**NE_ENUM_INT_3**

On entry, **side** = $\langle value \rangle$, **m** = $\langle value \rangle$, **n** = $\langle value \rangle$ and **k** = $\langle value \rangle$.
Constraint: if **side** = Nag_LeftSide, **m** $\geq$ **k** $\geq$ 0;
if **side** = Nag_RightSide, **n** $\geq$ **k** $\geq$ 0.

On entry, **side** = $\langle value \rangle$, **m** = $\langle value \rangle$, **n** = $\langle value \rangle$ and **l** = $\langle value \rangle$.
Constraint: if **side** = Nag_LeftSide, **m** $\geq$ **l** $\geq$ 0;
if **side** = Nag_RightSide, **n** $\geq$ **l** $\geq$ 0.

On entry, **side** $= \langle value \rangle$, **pda** $= \langle value \rangle$, **m** $= \langle value \rangle$ and **n** $= \langle value \rangle$.
Constraint: if **side** $=$ Nag_LeftSide, **pda** $\geq \max(1, \mathbf{m})$;
if **side** $=$ Nag_RightSide, **pda** $\geq \max(1, \mathbf{n})$.

**NE_INT**

On entry, **m** $= \langle value \rangle$.
Constraint: **m** $\geq 0$.

On entry, **n** $= \langle value \rangle$.
Constraint: **n** $\geq 0$.

On entry, **pda** $= \langle value \rangle$.
Constraint: **pda** $> 0$.

On entry, **pdc** $= \langle value \rangle$.
Constraint: **pdc** $> 0$.

**NE_INT_2**

On entry, **pda** $= \langle value \rangle$ and **k** $= \langle value \rangle$.
Constraint: **pda** $\geq \max(1, \mathbf{k})$.

On entry, **pdc** $= \langle value \rangle$ and **m** $= \langle value \rangle$.
Constraint: **pdc** $\geq \max(1, \mathbf{m})$.

On entry, **pdc** $= \langle value \rangle$ and **n** $= \langle value \rangle$.
Constraint: **pdc** $\geq \max(1, \mathbf{n})$.

**NE_INTERNAL_ERROR**

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

## 7 Accuracy

The computed result differs from the exact result by a matrix $E$ such that

$$\|E\|_2 = O\,\epsilon\|C\|_2$$

where $\epsilon$ is the **machine precision**.

## 8 Parallelism and Performance

nag_dormrz (f08bkc) is not threaded by NAG in any implementation.

nag_dormrz (f08bkc) makes calls to BLAS and/or LAPACK routines, which may be threaded within the vendor library used by this implementation. Consult the documentation for the vendor library for further information.

Please consult the Users' Note for your implementation for any additional implementation-specific information.

## 9 Further Comments

The total number of floating-point operations is approximately $4nlk$ if **side** $=$ Nag_LeftSide and $4mlk$ if **side** $=$ Nag_RightSide.

The complex analogue of this function is nag_zunmrz (f08bxc).

## 10 Example

See Section 10 in nag_dtzrzf (f08bhc).